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REFRACTION OF UNDERWATER EXPLOSION SHOCK WAVES:
PRESSURE HISTORIES MEASURED AT CAUSTICS IN A FLOODED QUARRY

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UNITED STATES NAVAL ORDNANCE LABORATORY, WHITE OAK, MARYLAND

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REFRACTION OF UNDERWATER EXPLOSION SHOCK WAVES:
PRESSURE HISTORIES MEASURED AT CAUSTICS IN A FLOODED QUARRY

by

Robert M. Barash
Jean A. Goertner

ABSTRACT: High explosive charges were fired in a flooded quarry having a refractive sound velocity structure, in order to observe shock wave pressure histories at caustics, or focal surfaces. For such regions, present theoretical understanding and conventional acoustic ray-tracing techniques are inadequate. Peak pressure amplification factors up to 5.8 were measured; the smaller the charge, the more extreme the focusing. Energy flux density was also enhanced, but impulse per unit area was relatively unaffected.

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REFRACTION OF UNDERWATER EXPLOSION SHOCK WAVES: PRESSURE HISTORIES MEASURED AT CAUSTICS IN A FLOODED QUARRY

A continuing study is being made of the refractive effects of oceanic sound velocity gradients upon the propagation of shock waves from large underwater explosions. This report gives the results of a small-scale experimental investigation of shock wave focusing. This work was performed under Task RRRE 51001/212-8/F008-21-03 (NWER 14.088) and was supported by the Defense Atomic Support Agency.

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Commander

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By direction

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TABLES

SYMBOLS AND UNITS

Symbol	Units	Explanation
z	ft	depth
z_c	ft	observed depth of caustic for given shot
x	ft	horizontal charge-to-gage distance
R	ft	radial charge-to-gage distance
W	lb	charge weight
p	lb/in^2	pressure, above hydrostatic
t	specified	time
$p_{m(iso)}$	lb/in^2	initial shock wave peak pressure in isovelocity water
θ	time units	time constant of exponential decay
p_m	lb/in^2	maximum p in refractive water for given pressure-time record
F_p	dimensionless	peak pressure amplification factor, defined by $F_p = \frac{p_m}{p_{m(iso)}}$
$F_{p(max)}$	dimensionless	maximum F_p measured on smoothed curve of F_p vs $(z - z_c)$ for a given test condition
T_z	ft	vertical caustic thickness as defined in Section VI. B.
p_1	lb/in^2	maximum p observed for first caustic-related arrival
p_2	lb/in^2	maximum p observed for second caustic-related arrival; multi-peak records only
$p_{1(rise)}$	lb/in^2	p_1 - precursor pressure at $t = t_c$
I	lb/in^2-sec	"total impulse" in refractive water, defined by $I = \int_0^{t_i} p\,dt$
I_c	lb/in^2-sec	"caustic-related impulse" in refractive water, defined by $I_c = \int_{t_c}^{t_i} p\,dt$
t_c	time units	arrival time of first caustic-related pressure increase

SYMBOLS AND UNITS (continued)

Symbol	Units	Explanation
t_i	time units	upper integration limit used in this study for pulses in refractive water; $t = t_i$ at $p = .07\ p_m$
F_I	dimensionless	impulse amplification factor for "total impulse" $F_I = \dfrac{I}{\left(\int_0^{5\theta} p\ dt\right)_{iso}}$
F_{I_c}	dimensionless	impulse amplification factor for "caustic-related impulse" $F_{I_c} = \dfrac{I_c}{\left(\int_0^{5\theta} p\ dt\right)_{iso}}$
F_E	dimensionless	energy amplification factor, defined by $F_E = \dfrac{\left[\int_0^{t_i} p^2\ dt\right]_{refr}}{\left[\int_0^{5\theta} p^2\ dt\right]_{iso}}$
$F_{E(max)}$	dimensionless	maximum F_E measured on smoothed curve of F_E vs $(z - z_c)$ for a given shot

REFRACTION OF UNDERWATER EXPLOSION SHOCK WAVES: PRESSURE HISTORIES MEASURED AT CAUSTICS IN A FLOODED QUARRY

I. INTRODUCTION

Experimental and theoretical studies (Refs. 1, 2, 3)* have shown that the propagation of underwater explosion shock waves can be strongly influenced by gradients in the propagation velocity. Such gradients, which commonly occur in the ocean, refract pressure waves so that at particular points of observation, the pressure amplitudes and wave shapes (pressure vs time) may differ from those that would have been observed in isovelocity water.

There is particular interest in those regions of the pressure field where the shock wave is focused. Focal points, lines, and surfaces are called caustics. Underwater acoustic and shock wave propagation experiments have verified theoretical indications that pressure amplitudes at and near caustics can be substantially greater than those that would be expected in the absence of refraction.

The quantitative prediction of shock wave pressures at caustics is a difficult problem. The conventional ray tracing methods that are commonly used for acoustic refraction calculations are not rigorously valid for a pressure pulse that has a broad frequency spectrum, that emanates from a source of finite size rather than from a point source, and that has a finite (non-acoustic) amplitude. Although these conventional methods yield acceptable predictions in many regions of a refractive field, their limitations become critical in caustic regions (Ref. 1). In particular, unmodified conventional ray calculations unrealistically indicate infinite pressure at the caustic.

The experiment reported here was performed in order to obtain the data required for a better theoretical understanding of the caustic and for the development of improved prediction methods.

Explosive charges were fired in a flooded quarry having a sound velocity structure that was a scale model of a common type of oceanic sound velocity structure. The innovation in this experiment was the concentration of a finely-spaced array of pressure gages at the caustic in order to observe in detail the spatial variation of the pressure pulses in this region.

II. SUMMARY OF RESULTS

Pressure histories in the region of the caustic were observed as a function of charge size, firing depth, and distance from the charge.

* References are given on page 13.

Each pressure history exhibits up to four arrivals, each identifiable by its characteristic pressure-vs-time form and by the angle at which the particular wave front was observed to sweep across the gage array.

The peak pressure in the pulse was observed to undergo refractive amplification by factors up to 5.8, depending upon the test conditions. In general, the smaller the charge size, the sharper is the region of focusing and the greater is the maximum value (i.e., right on the caustic itself) of the peak pressure amplification factor. Although the degree of focusing was observed to vary also with variations in the firing depth and the distance from the charge, no reliable uniform trends were discernible.

The refractive amplification of shock wave energy flux density appears to occur in a similar manner and with roughly similar magnitudes to the peak pressure amplification. Except at the close-in ranges, however, maximum energy amplification apparently takes place below rather than at the caustic depth.

Shock wave impulse amplification factors remain much closer to unity than do the peak pressure and energy factors. Values of impulse factor do not go through a maximum at the caustic position.

These results are described and discussed more fully in Sections V and VI. A comparison of the experimental results with theory is in progress but is not reported herein.

III. EXPERIMENTAL ARRANGEMENTS

The experiment was performed during August-September 1964 in a flooded quarry known as Dickerson Quarry, near Dickerson, Maryland. Figure 1 is a photograph of the experimental layout.

The quarry extends 250 ft x 500 ft, and has a maximum water depth of 70 ft. No currents were discernible. The surface state varied from glassy to having small ripples.

The main longitudinal wire cable, with plastic foam floats attached, was extended between two rafts which were restrained by ropes tied to trees. The 15 pressure gages were suspended through a hole in the gage raft. The charge was suspended from a point along the longitudinal cable, at a horizontal range which varied from 160 ft to 300 ft on the various shots. One vertical string of electrical temperature sensors was suspended from a float at Temperature Station 1, 15 ft laterally from the gage raft; and a second string was at Station 2, near the charge end of the quarry. The various signal and control cables, all with foam floats, extended to the instrumentation trailers at the edge of the quarry.

The 32 charges were bare, centrally-detonated, cast pentolite spheres of four different weights, approximately 1/8, 1, 8, and 53 lbs. Charges were fired at depths of 25, 35, and 50 ft.

The pressure sensors were 1/2-inch diameter tourmaline piezoelectric gages, with a Bostik coating that appears to yield a somewhat more valid and reproducible gage response than the wax coatings used in previous experiments.

The gages were mounted on wires stretched along a steel frame, as shown in Figure 2. The gages were, at first, spaced over a 32-inch vertical span, with one-inch vertical spacing at the center of the array and increasingly greater spacing toward the top and bottom. Then, beginning with Shot 1097, the vertical spacings were increased--roughly doubled. The gages were staggered laterally, in order to increase the distances between gages and thereby minimize mechanical reflections of the pulses. The gage frame was suspended, by several sections of pipe, from a gallows over the hole in the gage raft. The depth of the gage frame was varied by raising and lowering the pipe, removing and adding sections. The gages were directed edge-on toward the charge.

Voltages proportional to the instantaneous pressures sensed by each gage were displayed as vertical deflections of a spot on an oscilloscope. The deflections were photographed by a rotating drum camera, to produce pressure-vs-time traces. The upper limit of the frequency response of the recording system was determined largely by the size of the gage; a sudden rise in pressure was recorded with a 10 μsec rise time.

The temperature sensors were thermistors spaced along a vertical array suspended from each of the two temperature station locations. There were 15 thermistors at Station 1 and 8 thermistors at Station 2. Near each shot time the thermistors were sequentially switched into a special bridge circuit in the instrumentation trailer, and temperatures were read on a direct-reading meter.

We endeavored to place the center of the gage array at the depth of the caustic on each shot. For most shots this was attempted by probing for the caustic produced by an acoustic signal. First, the gage array was centered at the caustic depth expected on the basis of calculations for a pre-experiment profile, or on the basis of data from preceding shots. Then, after the charge was placed, an expendable piezoelectric transducer at the charge location was repeatedly driven to produce an acoustic pulse, while the gage frame was raised and lowered incrementally. The output of a hydrophone mounted at the center of the gage array was observed on an oscilloscope to determine the depth of the caustic. It was expected that this depth would be indicated by a maximum in the amplitude of the received pulse and by the vanishing of the time difference between the two caustic-related pulses. Unfortunately, however, the transducer produced an oscillating output which in many cases made the interpretation ambiguous. Even so, the placement of the gage array turned out to be adequately successful throughout the experiment.

IV. GENERAL NATURE OF THE EXPECTED PRESSURE FIELD

Figure 3 shows the type of velocity profile which occurred in the quarry and the resultant ray diagram calculated for it. This profile has been slightly idealized in order to incorporate all the major features encountered throughout the experiment and show how the location of the gage string was varied in an attempt to make measurements in the several regions of interest.

Consider a charge fired at 35-ft depth and a pressure gage at 30-ft depth placed at any horizontal distance out to about 150 ft. Such a gage would register a pressure pulse arriving along a slightly bent but fairly direct path from the charge. This pulse should look like a "typical" shock wave propagated in isovelocity water. As we move the gage farther away from the source, however, we see that in addition to a direct shock arrival, we will be measuring other pulses which have traveled via different routes at varying velocities.

Suppose we now place our gage at a range of 260 ft and vary its depth. What will be the effect on the pressure-time histories? Let us first consider a gage placed at the caustic. This is a region in which adjacent rays converge and intersect rather than diverging as under isovelocity conditions. One would expect a gage placed at the caustic to measure a pressure higher than that in the isovelocity case since there is a focusing of energy here. If we now move our gage deeper, we see that there will be two different groups of rays reaching it: those approaching the caustic along a fairly direct path (to be designated as the "first caustic-related arrival") and those reaching the gage after having already touched the caustic (to be designated as the "second caustic-related arrival"). The groups arrive in this order because the greater average velocity of the second group of rays does not quite compensate for their longer path of travel. One would expect to see double-peaked pressure-time histories in this region. The farther below the caustic the gage is placed, the greater will be the time difference between the two arrivals. Just above the caustic is a region called the "pseudo-shadow zone", into which no conventionally computed rays penetrate.

Another type of arrival we can trace is the wave reflected from the free water surface as a rarefaction wave. This pulse, which travels a longer ray path, is usually evident as a pressure decrease superimposed on the positive pressure pulse when the reflected wave arrives at the gage. The first portions of the reflected paths are shown as dashed lines.

With different charge depths and changing temperature conditions, the actual position of the caustic formed by the major velocity gradient of the quarry profiles varied from shot to shot. In some cases, the calculated caustic had two branches. Also, a shallow caustic sometimes occurred on warm afternoons as a result of a small negative gradient near the water surface.

V. EXPERIMENTAL DATA

A. Long-Range Data

The coordinates of the pressure-vs-time traces and calibrating traces on the film records were measured on a Telereadex, a mechanical record reader with punched-card output. Resulting data points were processed by an IBM 7090 computer and a CalComp plotter, to produce plots of pressure* vs time, both in conventional units and in reduced units. All the plots of the latter type are shown in Figure 4. In these plots, unit pressure and unit time are the peak pressure and the decay constant, respectively, of a pulse that would be expected** at the particular gage location if refractive effects were absent.

In Figure 4 the shots are grouped according to test conditions: charge weight, firing depth, and horizontal range. For each shot the records are shown in order of increasing gage depth and are aligned in time, not with respect to an absolute time reference, but rather to the time of each record's own first observable pressure signal. All records are drawn to the same scale of the reduced units, $p/p_{m(iso)}$ vs t/θ. An unrefracted pulse, having isovelocity values of $p_{m(iso)}$ and θ, and drawn to the same scale, is shown for comparison purposes in Figure 4a.

Table I presents the values of several useful types of quantities derived from the pressure records. First, for each gage depth, the highest observed pressure (above hydrostatic) for each measurable peak is given. Also included is the increase in pressure at $t = t_c$ due to the first (or only) caustic-related arrival, along with the ratio of this pressure rise to $p_{m(iso)}$. The quantity p_m is the maximum shock wave pressure observed (or extrapolated***) in a particular record; values of $\int p\,dt$ and $\int p^2\,dt$ are also presented. In addition, Table I lists amplification factors (as defined in List of Symbols) for p_m, $\int p\,dt$, and $\int p^2\,dt$.

An especially significant quantity is the peak pressure amplification factor, F_p, defined as $p_m/p_{m(iso)}$. This quantity indicates the

* All pressures are measured as excess above hydrostatic.

** "Expected" isovelocity peak pressures were obtained by averaging the values computed with the two similitude equations reported in Refs. 4 and 5 for pentolite. The similitude equations are empirical descriptions of $p_{m(iso)}$ as a function of $W^{1/3}/R$ in homogeneous water.

*** Extrapolation is performed to compensate for distortion in the recorded pressure peak due to the finite size of the gage. Because of the great variation in pulse shapes, the usual method of determining p_m by a straight-line extrapolation on a semi-log plot, suitable for exponentially-decaying pulses, was not used. (See Ref. 6). Rather, a linear plot was used, and a simple straight-line extension of the initial decay back 5 μsecs (~1/2 the gage transit time) from the apparent peak was made. Only those peaks whose sharpness was obviously limited by gage response were extrapolated. This method of extrapolation is admittedly subjective.

observed peak pressure relative to that which would have been observed in isovelocity water, all other things being equal. Thus, the pressure factor completely suppresses the first order effects of charge yield and test geometry upon the peak pressure and indicates only the effects of refraction and of the interactions of refraction with charge size and test geometry. These interactions are the primary interest of this study.

In order to compare values of impulse and energy flux among the refractive pulses and with reference isovelocity pulses, comparable durations must be used for integration of the pressure-time histories. Figure 5 shows sketches of a typical pressure pulse in isovelocity water (approximated as $p = p_{m(iso)}\, e^{-t/\theta}$)* and a sample of one of the various pulse shapes obtained under refractive conditions. In explosive comparison studies, integrations of the simple exponentially-decaying pulses are usually carried out to the arbitrary standard limit $t = 5\theta$, as shown in Figure 5a, the isovelocity case. But a limit stated in terms of θ is not generally applicable to the shapes of refractive pulses. Study of records from previous isovelocity experiments indicates that at the time $t = 5\theta$, the pressure in the shock wave has fallen to roughly .07 of its value at the peak. For the present analysis, it was therefore decided to carry out integrations to the time, to be designated as t_i, at which the pressure has decreased to .07 p_m.

In the refractive case, as represented in Figure 5b, the pressure pulses vary in shape, with the "caustic-related" shock wave having one or more "peaks" and sometimes being preceded by an earlier arrival. The values reported for $\int_0^{t_i} p\, dt$ and $\int_0^{t_i} p^2\, dt$ were measured over the interval from the first observed increase in pressure ($t = 0$) to the time $t = t_i$. The first quantity has been designated as the "total impulse", I. In cases having arrivals preceding the first caustic-related shock front, "caustic-related impulse", I_c, designates $\int_{t_c}^{t_i} p\, dt$, where t_c = arrival time of first caustic-related pressure increase. The designation "caustic-related impulse" is not strictly accurate, since an undeterminable amount of non-caustic-related impulse may persist beyond t_c.

B. <u>Near-Field Data</u>

In addition to the string of gages at long ranges, one pressure gage was placed at a radial distance of 10 ft from the charge to obtain reference measurements of unrefracted pulses. $p_{m(iso)}$ and θ, the decay constant, were measured by extrapolation of semi-log plots of pressure vs time as in Ref. 6.

With the average of similitude values given by Ref. 4 and 5 as the standard for comparison, the average values of $p_{m(iso)}$ were generally high but within normal scatter for all but the smallest size charge; i.e., 4% high for the 53-lb charges, 8% for the 8-lb charges and 2% high for the 1-lb charge size. The 0.122-lb charges averaged 25% <u>lower</u>

* For general discussion of underwater explosion shock waves, see Ref. 7.

peak pressure than the average similitude values. But the peak pressure extrapolations in this case are unreliable because of very large oscillations in the traces.

The time constant, θ, fell within normal scatter even in the case of the smallest charges.

C. Velocity Profiles

From one to three sets of temperature readings were taken for each shot, with one as close as possible to (usually prior to) the time of firing. Temperatures were converted to sound velocities using Wilson's equation for distilled water (Ref. 8).

Velocity profiles for each station are tabulated in Table II. The accuracy of the values given is limited by precision of meter reading, of the calibration curves, and of Wilson's equation. It is estimated that the velocities may be in absolute error by as much as 2 ft/sec, but that the relative error within each profile, the more significant quantity in this experiment, is probably substantially smaller.

Figure 6 is a velocity profile plot showing average curves (using data points from both stations at one or more times close to shot time) for each of three different shots. These three profiles indicate the range of variation occurring during the firing program. Shot 1078 was the first shot fired (8/18/64); Shot 1091 was fired about midway in the series (8/31/64); Shot 1109, fired on 9/14/64, was the final shot of the program. In addition, the upper portion of the profile for Shot 1106 (9/11/64) is included to indicate the variations which occurred in the shallow layer with the passage of time.

The curve identified by a 5 was obtained on the day following the final shot. This profile is the result of lowering a single thermistor very slowly, with a much finer depth spacing between temperature readings than was employed previously. These measurements were made following an unusually cool and windy weekend, during which the surface layer cooled appreciably. Whether the gradient discontinuity observed in this profile was actually present during any of the firing program is not known. The profile shapes and locations of data points are such that a discontinuity prior to Shot 1099 seems highly unlikely. Subsequent to Shot 1099, however, the possibility seems to increase with the passage of time and cooling of the upper layer of water.

VI. DISCUSSION OF RESULTS

A. Arrival Times and Ray Angles

Using plots of arrival time vs gage depth, we can calculate for each shot the angle at which each particular pressure front traversed the vertical gage string. The scatter of data points in the present study, however, limited the accuracy. Table III lists the calculated angles of arrival of all four types of wave fronts observed: the first and the

second caustic-related arrivals, the precursor, and the surface-reflected arrival.

All four types of wave fronts arrived at small downward angles, sweeping across the gage string from top to bottom. In each case the first caustic-related wave front arrived along the smallest downward ray angle, and the second arrived along a slightly greater downward angle. The precursor, in cases where present, usually arrived at a greater angle, and the surface-reflected wave usually arrived at the greatest angle.

The application of Snell's Law to the arrival angle of the precursor wave front indicates that the beginning of the precursor arrived along a ray having a vertex velocity such that its vertex must have occurred somewhere within the high-velocity near-surface layer. This indication is consistent with the finding that the precursor occurs only at gages in regions where the calculations show this type of arrival to be possible.

The angles listed in Table III were determined assuming a vertical gage array. During the ray angle analysis, it was found that the array probably deviated from vertical by about 1 to 3 degrees, with the top end tilted toward the charge. This was taken into account in determining the path of the precursor wave front.

B. Pressure Distribution in the Caustic Region*

The spatial variation of peak pressure amplification factor, F_p, in the caustic region is of major interest. For each set of shots having the same nominal test conditions, plots representing this variation were superimposed on the same graph in order to reduce the uncertainty due to experimental scatter. For the same test conditions, the plots appeared to have similar shapes; but the depths of maximum F_p varied somewhat--a result to be expected with a velocity profile that varied slightly from shot to shot. Therefore the superimposed plots are drawn with reference to each shot's depth of maximum F_p, designated as the caustic depth, rather than to the absolute depth. Figure 7 illustrates the difficulties one encounters in attempting to determine the depth of maximum F_p, especially if one or more points in this region appear to be in error. Figure 8 (a through n) shows the composite plots with the original data points and a smooth average curve drawn through them**.

* The two shots at 160-ft range (1091 and 1092) and the three shots with gages in the near-surface layer (1088, 1098, and 1101) are not included here, but are discussed separately in VI. E.

** A rough calculation was made of the deviation of data points above and below the average curves shown in these figures. Considering those conditions for which there was only one shot, the approximate spread of points was about ± 5%. For the cases with three or more shots at one nominal test condition, the overall spread of points was about ± 8%, with perhaps the same spread or slightly less in the immediate vicinity of the peak.

If we now use the average curves obtained in the above manner, we can attempt some comparisons among the various firing conditions tested. One must bear in mind when doing this, however, both the large degree of scatter, well documented over years of experience in underwater explosion shock wave measurements, and the probable errors resulting from the subjective nature of many of the measurements made during analysis of the present experiment.

The distribution of peak pressure amplification factors in the caustic region can be characterized by the sharpness of the curve of F_p vs vertical distance from the caustic. A quantitative measure of this sharpness can be obtained from the peak pressure amplification factor at the peak, $F_{p(max)}$, and the distance between the points of inflection of the curve, the quantity T_z*, which may be thought of as the vertical caustic thickness. $F_{p(max)}$ and T_z are listed in Table IV for all the test geometries and are plotted in Figures 10b and 10c vs charge diameter.

In Figures 9, 10, and 11, the smooth average curves from Figure 8 are compared with each other in combinations that illustrate the effects of varying, respectively, the charge depth, the charge size, and the range.

Figures 9a, 9b, and 9c illustrate, each for a different charge weight, the effect of varying the charge depth, while holding range constant at 300 ft. No uniform trends are apparent, for either $F_{p(max)}$ or T_z. However, this result does not disprove the existence of relationships too small to be discerned through the experimental scatter.

The effect of charge size (for charges fired at 35 ft and gages placed at a horizontal range of 300 ft) is indicated by the plot of average curves for all four charge weights tested (Fig. 10a). Here we can see that the general effect of increasing charge size is to broaden and flatten the curve (i.e., to decrease its sharpness).

The values of $F_{p(max)}$ from the curves of Figure 10a are plotted in Figure 10b as a function of charge diameter. $F_{p(max)}$ decreases substantially as charge diameter increases. The value of 5.1 for the smallest charge is about 38 percent higher than the value of 3.7 for the largest charge. It may be seen in Table IV that no trend of this magnitude is evident for the other test geometries.

The vertical caustic thicknesses from Figure 10a are plotted in Figure 10c as a function of charge diameter. T_z appears to be approximately proportional to the charge diameter, except for the smallest charge. This exception, and other data in Table IV, suggest the existence of a lower limit of about 0.7 ft in the quarry tests.

* In order to make the determination of T_z as objective as possible, this quantity was determined by observing the relative maxima and minima on plots of slopes of straight-line segments drawn between data points (i.e., $\frac{\Delta F_p}{\Delta z}$ vs z).

Figure 11 shows the effect of range upon the peak pressure amplification factor distribution. Curves are shown for 0.122-lb and 8-lb shots with a charge depth of 35 ft, for which data are available at three ranges. Figures 11a and 11b show that for both charge sizes, the curves are sharper at the 190-ft range than at the 300-ft range. The data for the 230-ft range, however, indicate a non-uniform trend which is inconsistent between the two charge weights. The reliability of the range effect data is therefore put in doubt. But for what it may be worth, Figure 11c suggests that a decrease in range from 300 ft to 190 ft sharpens the curve by about as much as does a decrease in charge weight from 8 lbs to 0.122 lb.

It should be noted that for the 0.122-lb charges the peak pressure values measured close to the charge (i.e., the isovelocity values) in this experiment fell approximately 25% below those predicted by previous studies (see Section V. B.). If this difference is indeed real, then for the smallest charges actual pressure factors are about 1/3 greater than are reported herein.

C. Impulse

According to the Impulse Theorem (Ref. 9), at a given point in an unbounded medium, the impulse of a pressure pulse, integrated to infinite time, is independent of the velocity structure of the medium. This implies that no matter what changes in peak pressure and pulse shape occur in refractive water, the impulse will be the same as it would have been at the same point under isovelocity conditions. Study of the pressure-time records from the present experiment indicates agreement with the finding of Ref. 1 that a refraction-induced increase in peak pressure is accompanied by a compensating tendency for the pulse to decay more rapidly than in isovelocity water.

The present data do not provide a rigorous test of the Impulse Theorem because the noise and the time constant of the recording system limit the time to which impulse can be accurately integrated. However, as a matter of interest, plots of impulse amplification factors for both "total impulse" (F_I) and "caustic-related impulse" (F_{I_c}) (both defined in List of Symbols) vs vertical distance from the caustic were made. Figures 12 (a through g) show a few representative plots, with the similitude values from Ref. 10 used for isovelocity impulse. For a straight line eye-fitted through each set of data points, the following general observations can be made*:

1. The impulse plots have no peak at the caustic. The general tendency, within the limits tested, appears to be an increase in impulse with increasing depth, regardless of caustic location. Also, in general, the smaller the charge, the larger the impulse amplification factor.

2. For records having no precursor: Except for the 1/8-lb shots, under all conditions tested the F_I lines fall close to unity; for the

* The three shallow layer shots (1088, 1098, 1101) are not included in this comparison since surface reflection occurred early in the decay.

smallest charge the impulse is 15 to 60% greater than isovelocity values.

3. For records having precursor, "total impulse": Except for 0.122-lb shots, all lines have nearly zero slope. The 53- and 8-lb values fall within about 10% of the isovelocity impulse; 1-lb shots give impulse amplification factors of 1.11 to 1.30.

4. For records having precursor, "caustic-related impulse": Since precursor impulse decreases with increasing depth because of arrival time relationships, all lines have definite negative slope. All 8-lb shots fall below the isovelocity value; some 1-lb shots lie below, some are slightly higher than isovelocity (up to 10%) for the deeper gage positions. The range of impulse amplification factor values for the 53-lb charges is from 0.6 to 0.9.

5. For 0.122-lb records having precursor: Measurements of "total impulse" for all gage positions lie above the isovelocity values. All F_I lines have negative slope, with values at the upper end of 1.65 to 1.9. "Caustic-related impulse" lines generally have greater slope, with the lower end falling below unity and the higher end about the same as or slightly lower than the "total impulse" line. The portions of these lines from double arrival records all fall above the isovelocity values.

D. Shock Wave Energy Flux Density

For simple pressure pulses having amplitudes as low as those observed in this experiment, the energy flux density is, to a close approximation, given by:

$$E = \frac{1}{\rho_o c_o} \int p^2 \, dt$$

where ρ_o and c_o are the ambient density and sound velocity of the water. This relationship is not strictly valid in cases where pressure waves from different directions are superimposed at the gage point. For the purpose of this report, we consider not strictly the energy flux density, but rather the measurable quantity $\frac{1}{\rho_o c_o} \int p^2 \, dt$. Differences in $\rho_o c_o$ will be ignored, since this quantity varies by only 1% in the cases analyzed here.

Using $\rho_o c_o = 5.26$ lb·sec·in^{-3} and average similitude values for energy flux density (Ref. 10), isovelocity values of $\int_0^{5\theta} p^2 \, dt$ were calculated for comparison with experimental data listed in Table I. Figure 13 (a through g) shows representative plots of energy amplification factor, F_E (defined in List of Symbols) vs vertical distance from the caustic. Although the scatter is large, some general observations can be made:

1. For all ranges, $F_{E(max)}$ increases as charge size is decreased.

2. For a given charge size, $F_{E(max)}$ increases with decreasing charge-to-gage distance (except for W = 8 at x = 190, which is based on one shot only).

3. $F_{E(max)}$ is approximately equal to the maximum peak pressure amplification factor, $F_{p(max)}$, for the 8- and 53-lb charges; but for the two smallest size charges, $F_{E(max)}$ increases at a faster rate than $F_{p(max)}$ as the gage is moved closer to the charge.

4. At x = 190, the F_E curves rise to a relatively sharp peak at the caustic, after which they fall off rapidly, so that the curve is nearly symmetrical about the caustic depth.

5. As range increases, the curves become broader, and the peak is reached at some point below rather than at the caustic. At x = 300, the peaks are very broad, and the curves maintain a fairly high level to depths well below the caustic, despite a decrease in corresponding pressures.

E. Additional Results

The preceding sections treat data from all but five of the 32 quarry shots. For two of these remaining shots (1091 and 1092), data were obtained in the region off the near end of the caustic (x = 160 ft). This is a region in which the rays do not cross but are converging. Therefore, we would expect peak pressures somewhat greater than isovelocity. The peak pressure amplification factors measured for these two shots ranged in value from 1.5 to 2.8.

For the other three shots (1088, 1098, and 1101), the gage string was placed near the surface in order to make measurements in a shallow caustic zone. On Shot 1088, for which either there was no shallow caustic or else the gage string was relatively far from the caustic, peak pressures were less than half the isovelocity values. On Shot 1101, for which the uppermost gages were close to the caustic, peak pressure amplification factors ranged up to ~ 0.9. The gage string passed through the caustic on Shot 1098 giving a maximum F_p of ~ 1.5. While this value, compared with even non-caustic peak pressure amplification factors discussed in previous sections at first may seem rather low for a caustic region, it is explainable by noting (see Fig. 3) that the caustic forms from an already highly-divergent group of rays.

ACKNOWLEDGEMENTS

The need for and the concept of this experiment were suggested by Dr. Hans G. Snay of the Explosions Research Department. The experimental team was led by Bernard E. Cox and included Wilfred W. Hammack, Richard L. Marbury, Denard L. Marks, and Harold G. Thomas. Robert Thrun calculated refraction patterns before and during the experiment. Jean Rowe performed the basic data reduction. T. M. Leibig of the Public Works Department handled arrangements for sub-leasing the quarry from the Hydrospace Research Corporation, Rockville, Maryland.

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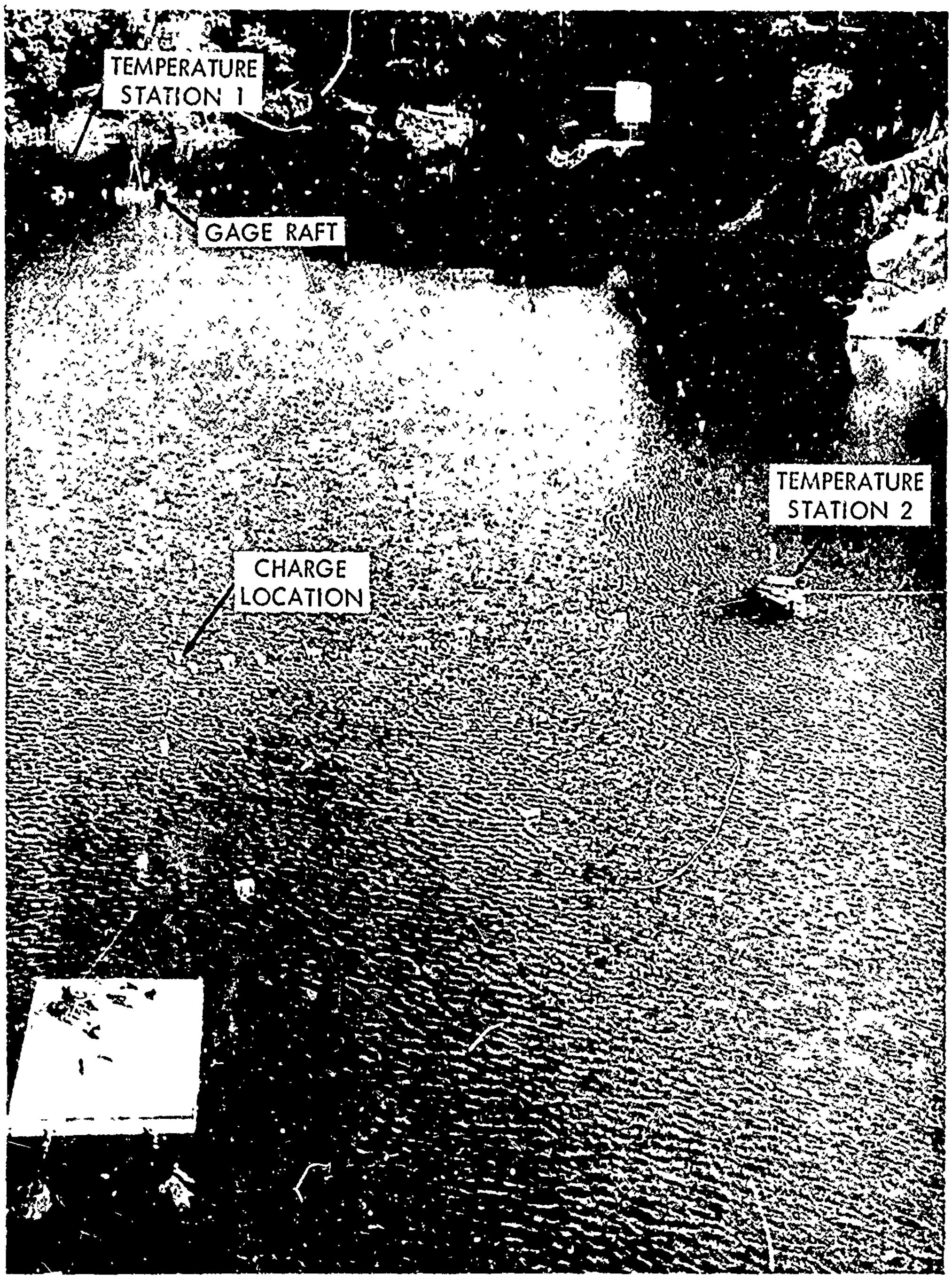


FIG. 1 EXPERIMENTAL LAYOUT

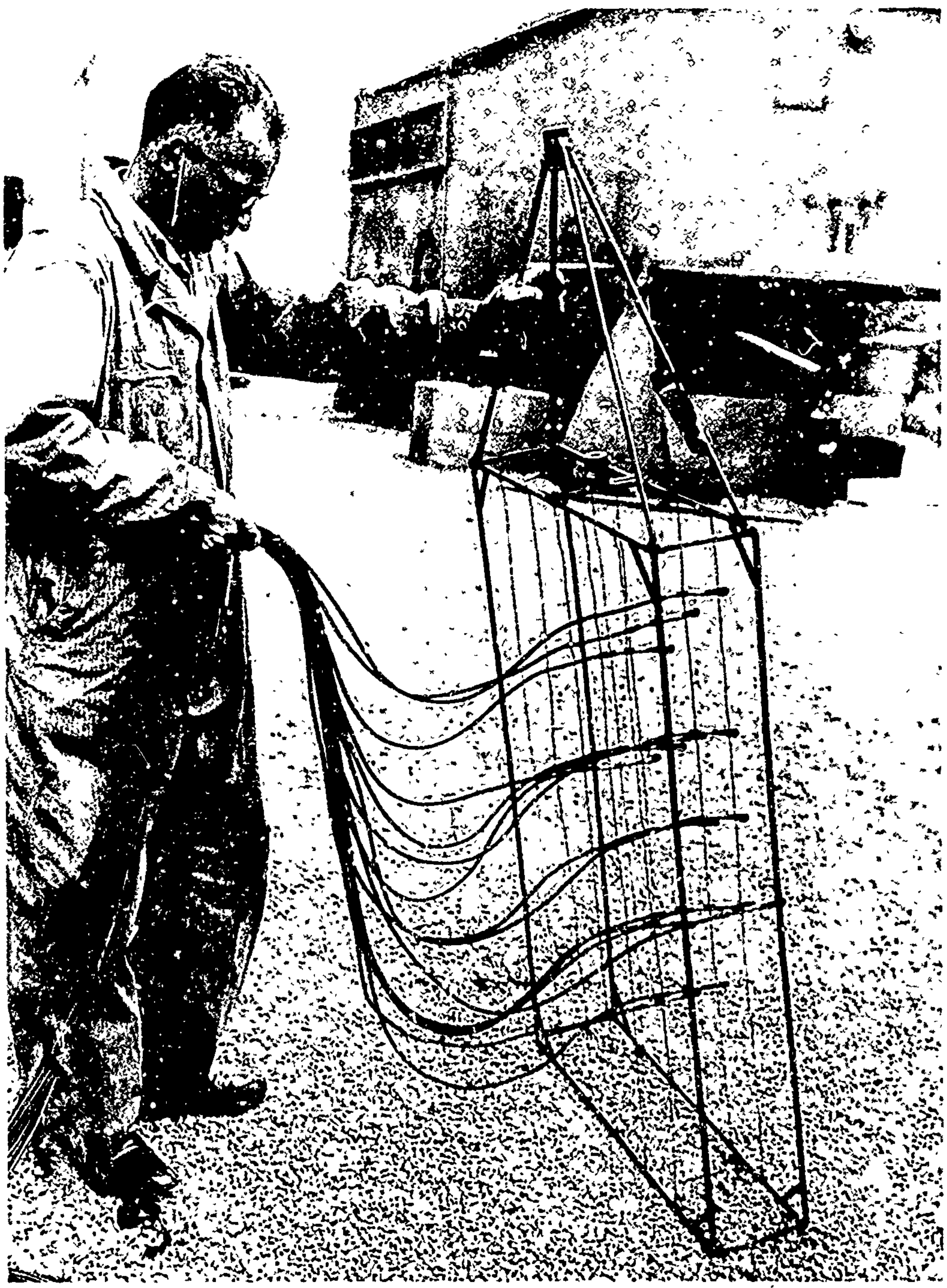


FIG. 2 GAGE RIG

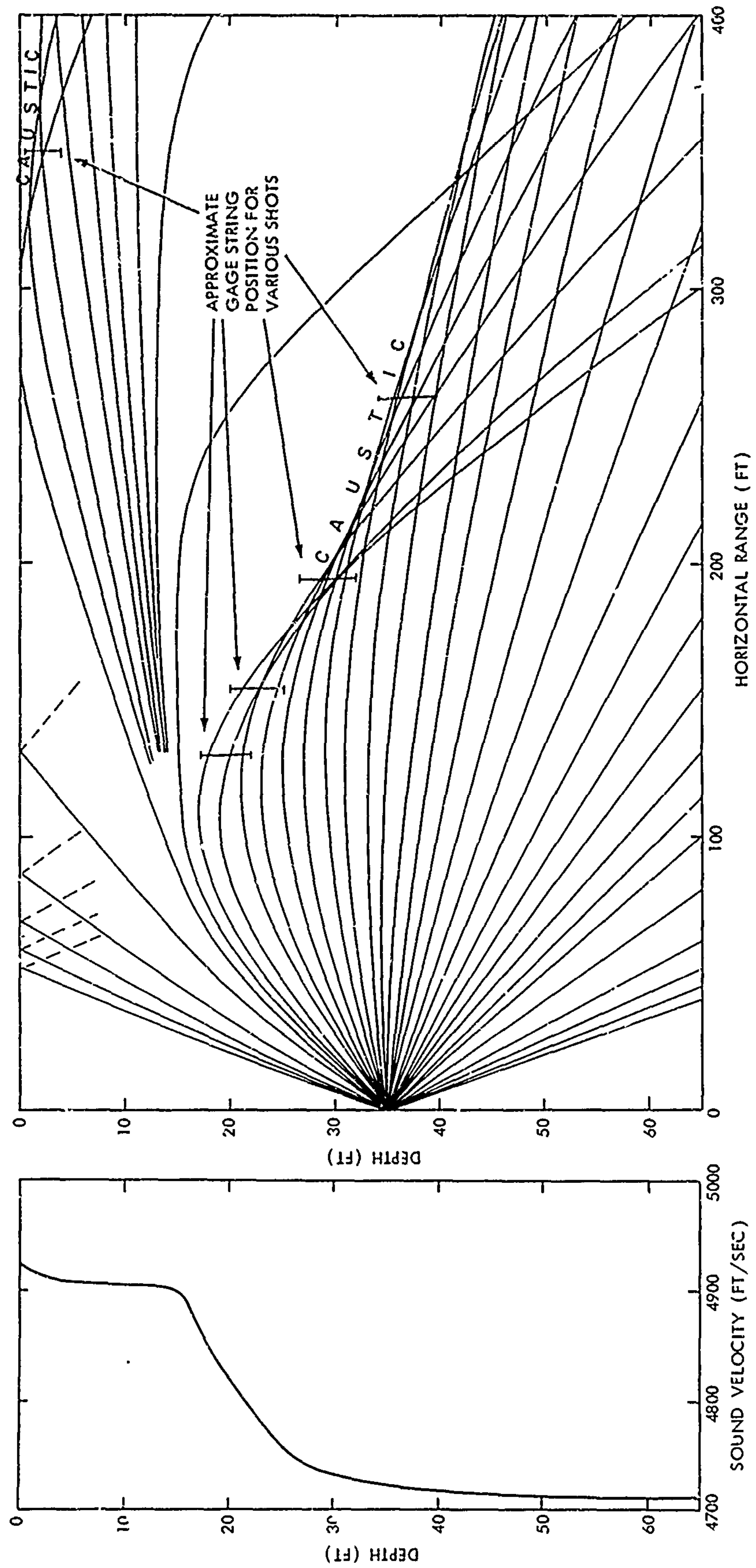
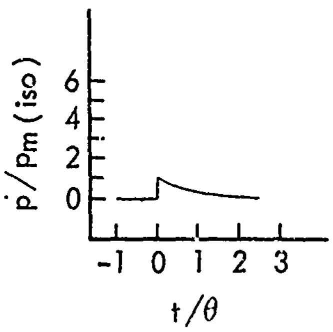


FIG. 3 IDEALIZED SOUND-VELOCITY PROFILE AND RAY DIAGRAM



For purposes of making direct comparisons with isovelocity and other refractive pulses, all plots in Figure 4 (b through g) are drawn to the same reduced pressure and time scales as the isovelocity pulse shown above. Each curve is preceded by a baseline of length $t = \theta$.

FIG. 4a REDUCED PRESSURE-TIME PLOT FOR AN ISOVELOCITY PULSE

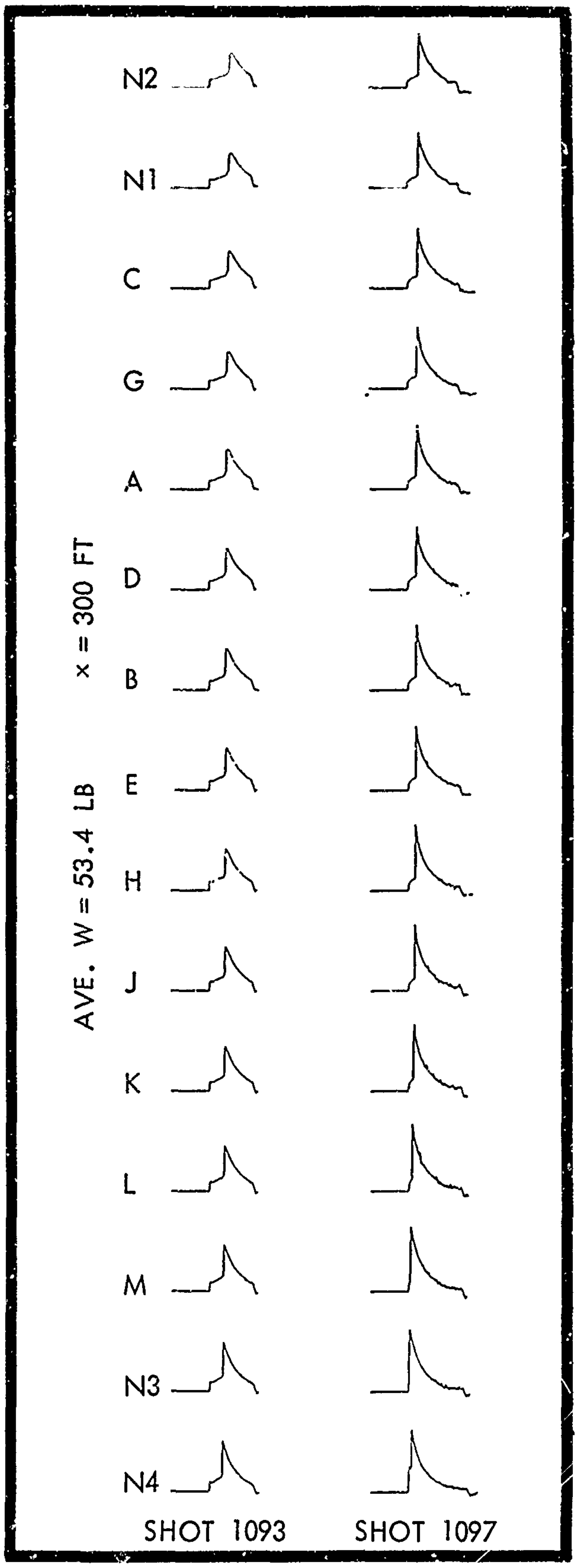
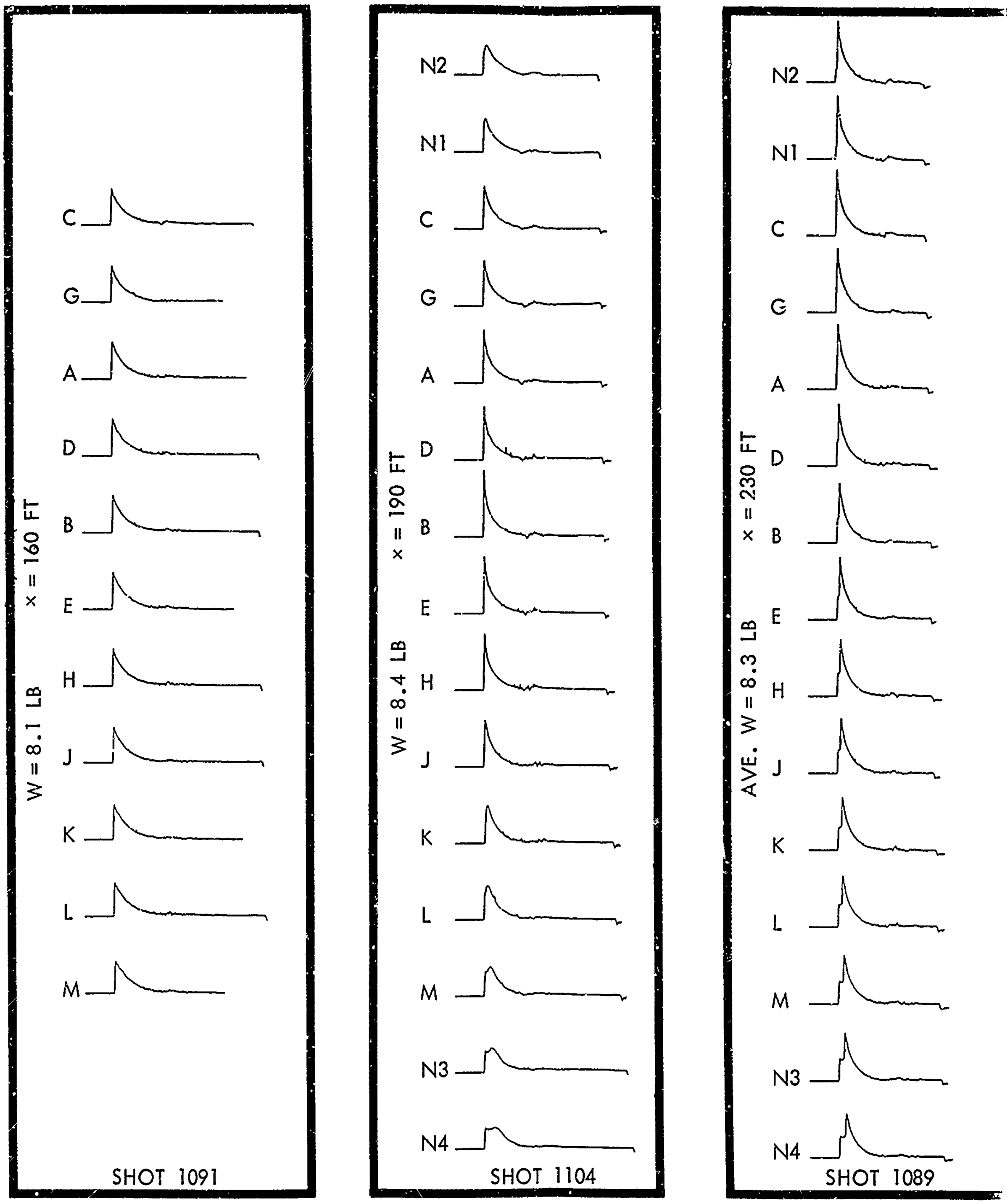


FIG. 4b REDUCED PRESSURE-TIME PLOTS FOR 53-LB CHARGES FIRED AT 35-FT DEPTH


C
G
A
D
B
E
H
J
K
L
M
W = 8.1 LB
x = 160 FT
SHOT 1091
N2
N1
C
G
A
D
B
E
H
J
K
L
M
N3
N4
W = 8.4 LB
x = 190 FT
SHOT 1104
N2
N1
C
G
A
D
B
E
H
J
K
L
M
N3
N4
AVE. W = 8.3 LB
x = 230 FT
SHOT 1089

A

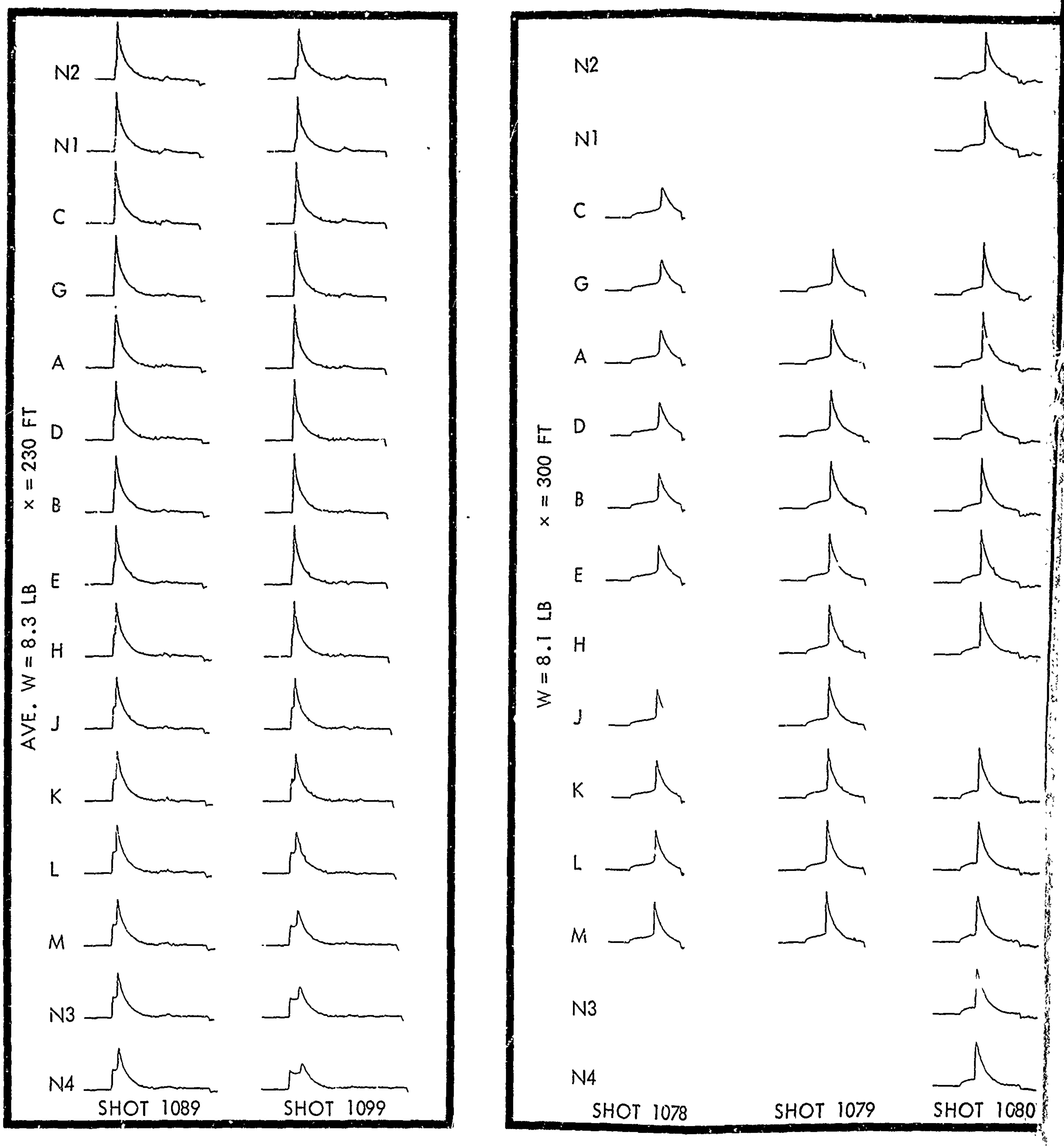


FIG. 4c REDUCED PRESSURE-TIME PLOTS FOR 8-LB

B

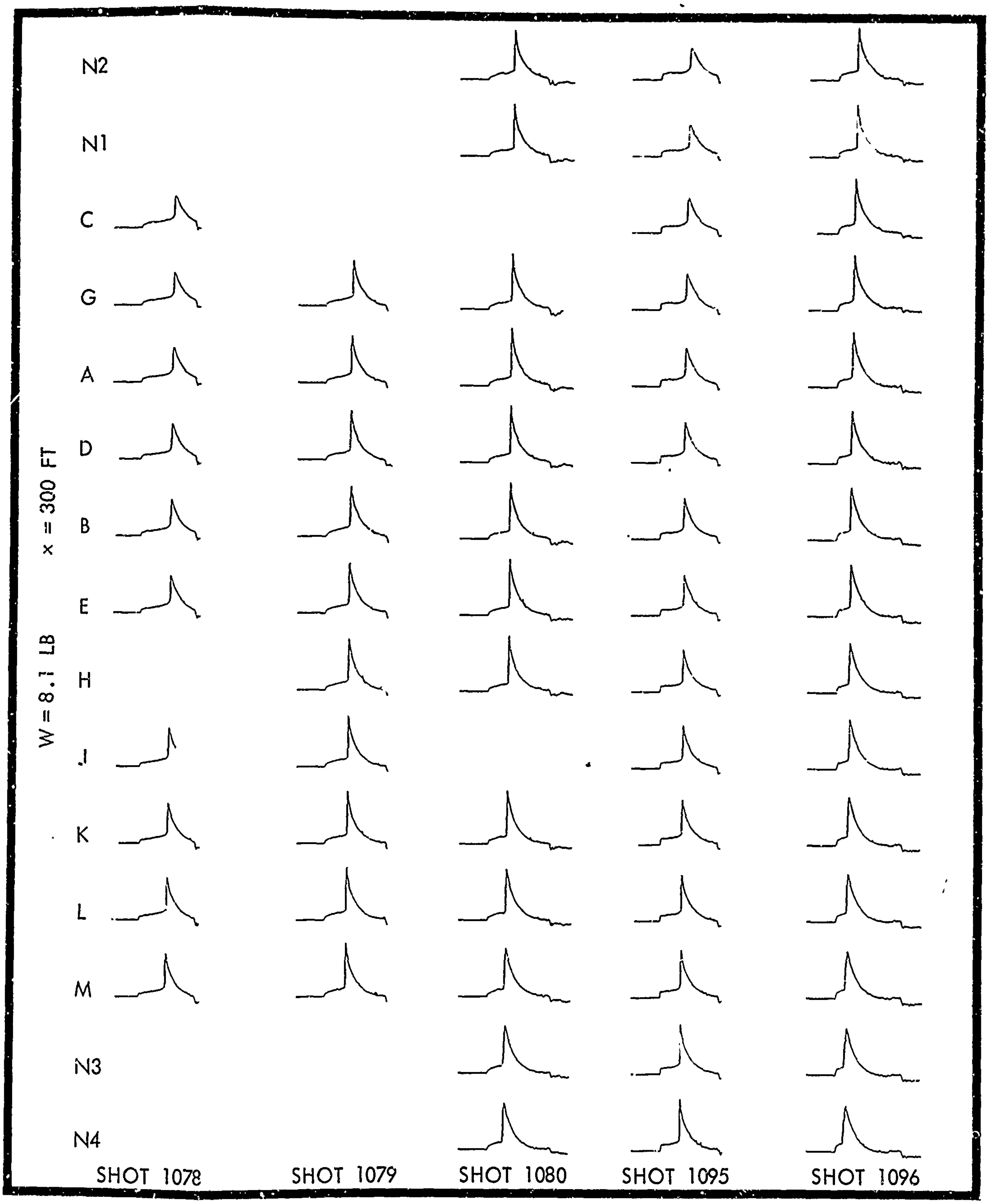


FIG. 4c REDUCED PRESSURE-TIME PLOTS FOR 8-LB CHARGES FIRED AT 35-FT DEPTH

C

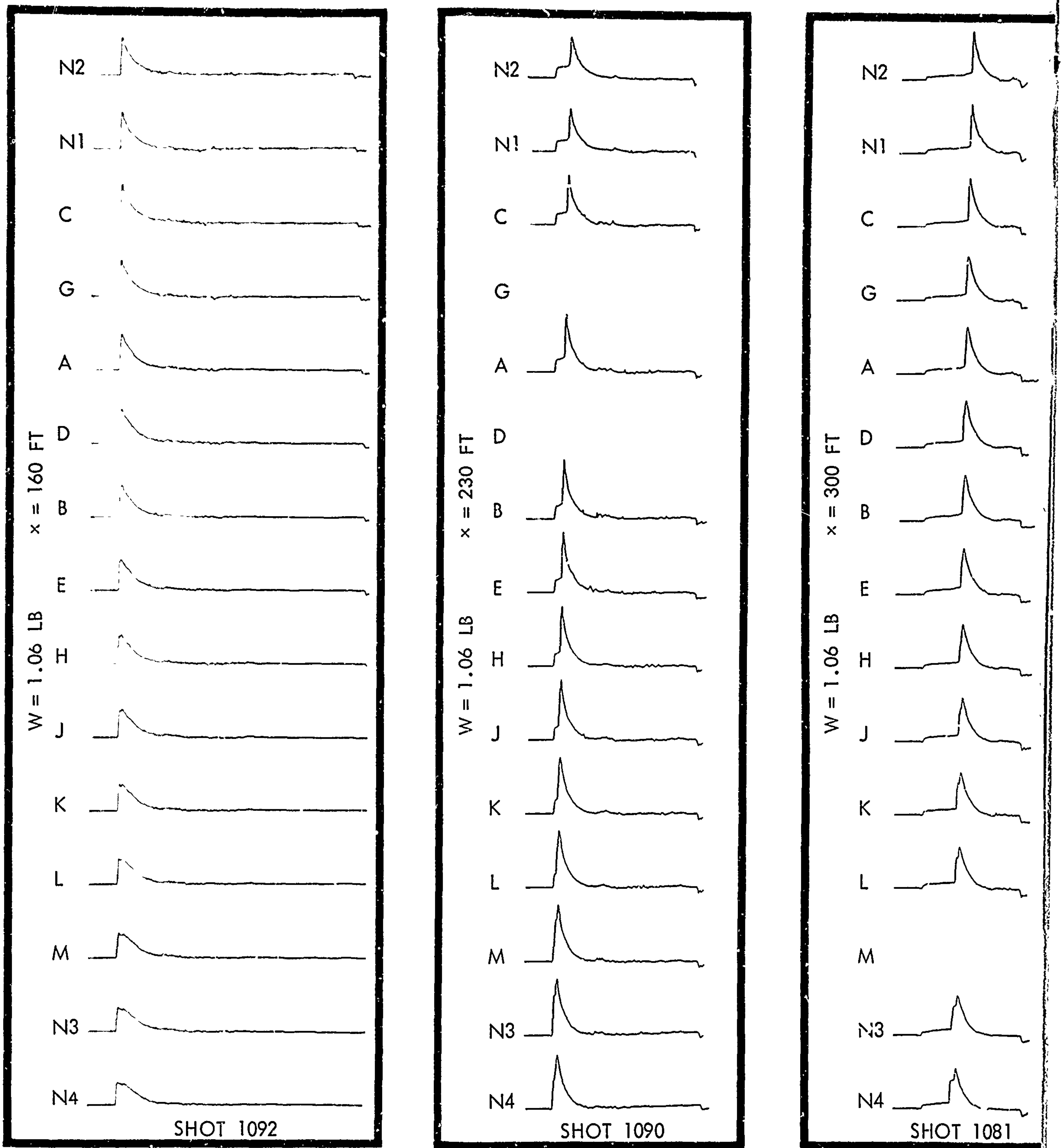


FIG. 4d REDUCED PRESSURE TIME PLOTS FOR 1-LB CHARG

A

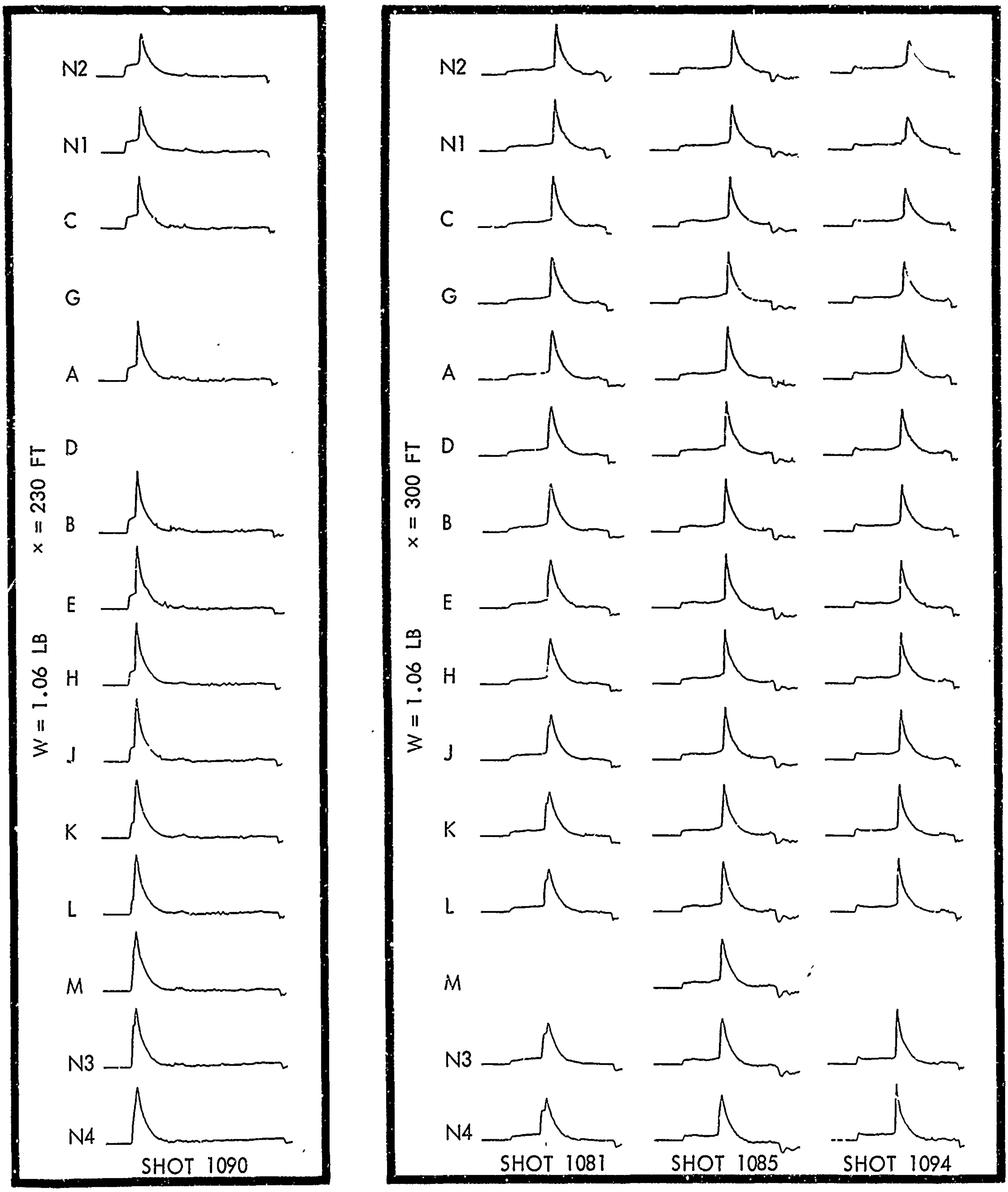


FIG. 4d REDUCED PRESSURE TIME PLOTS FOR 1-LB CHARGES FIRED AT 35-FT DEPTH

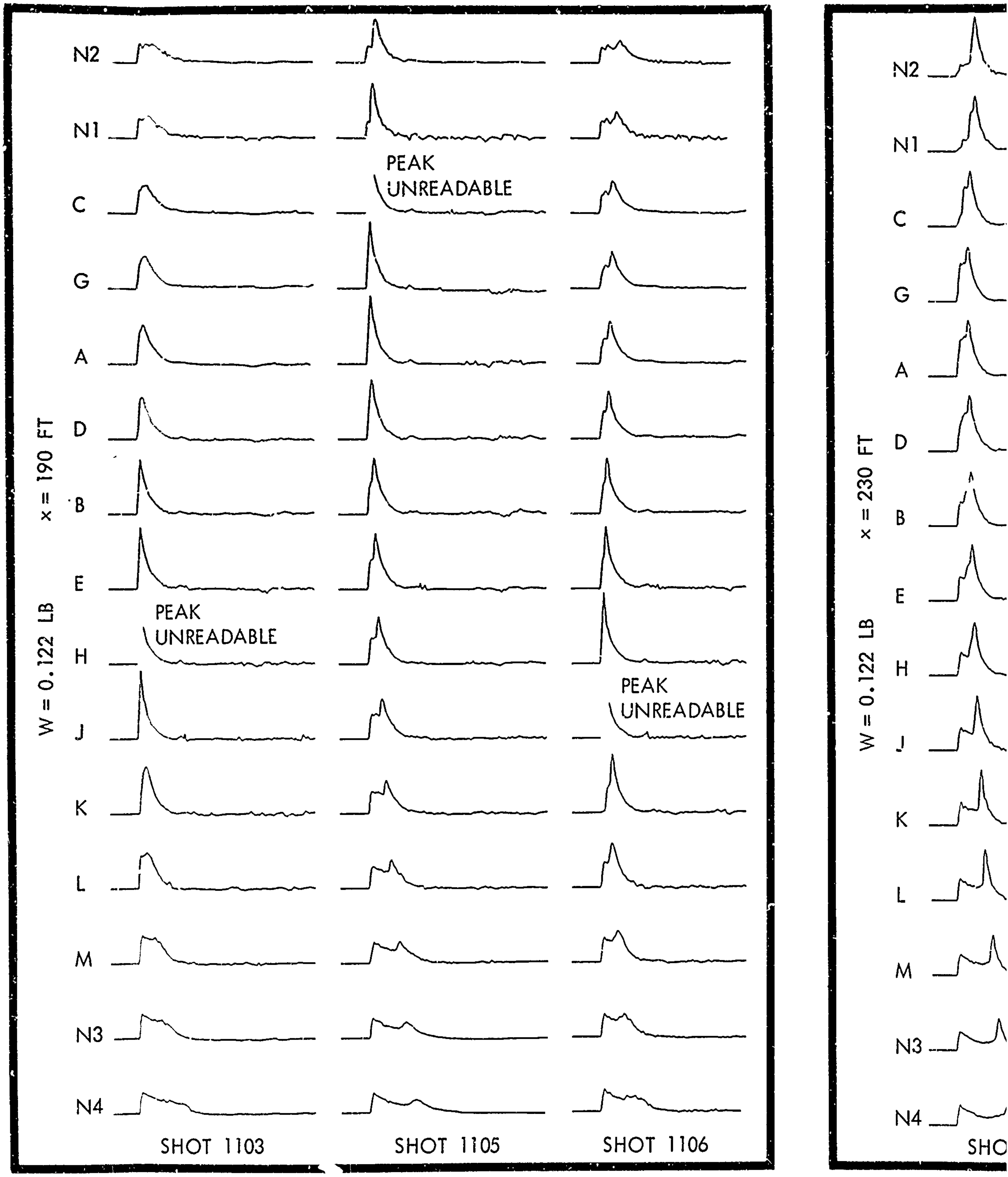


FIG. 4e REDUCED

A

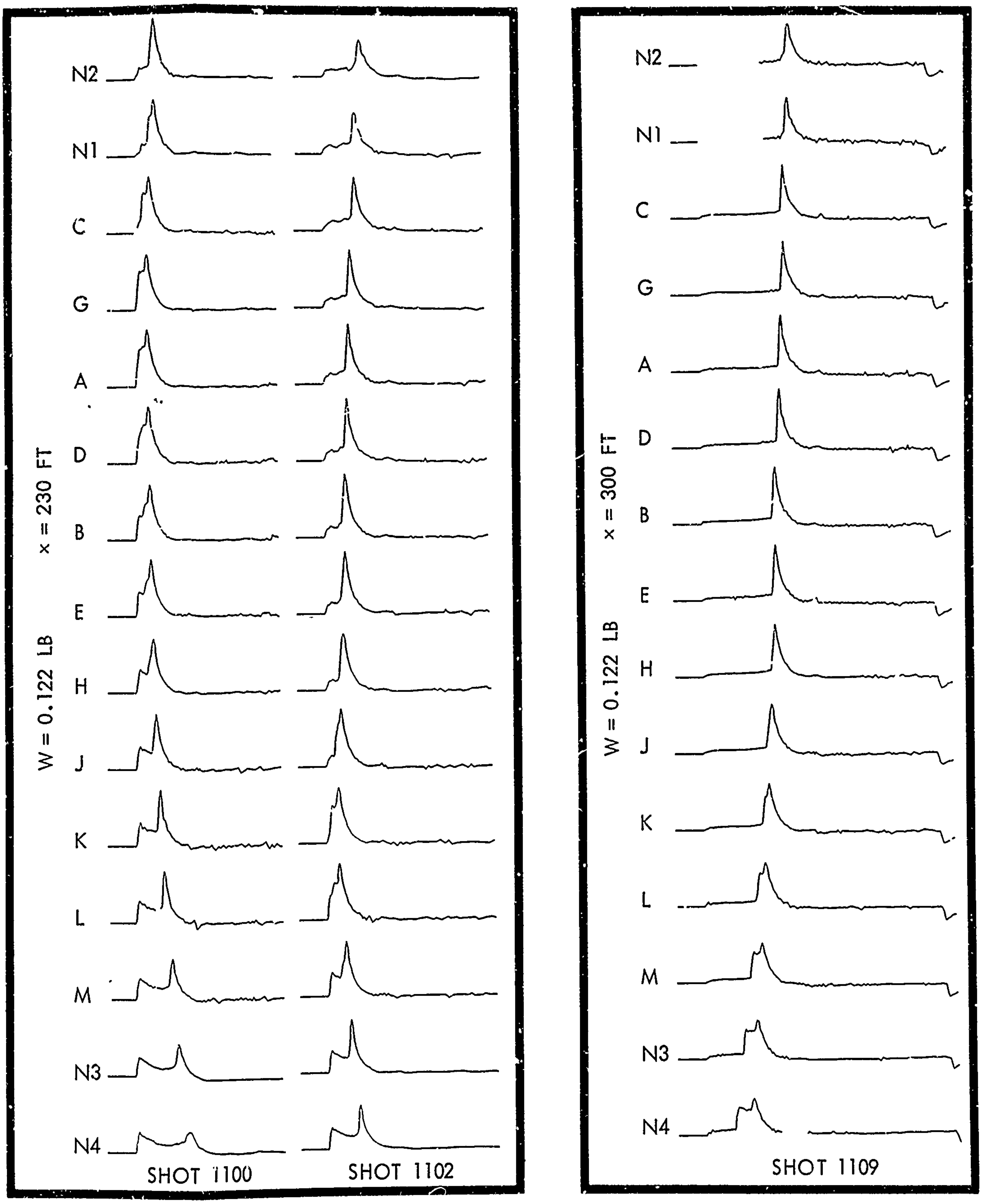


FIG. 4e REDUCED PRESSURE-TIME PLOTS FOR 0.122-LB CHARGES FIRED AT 35-FT DEPTH

6

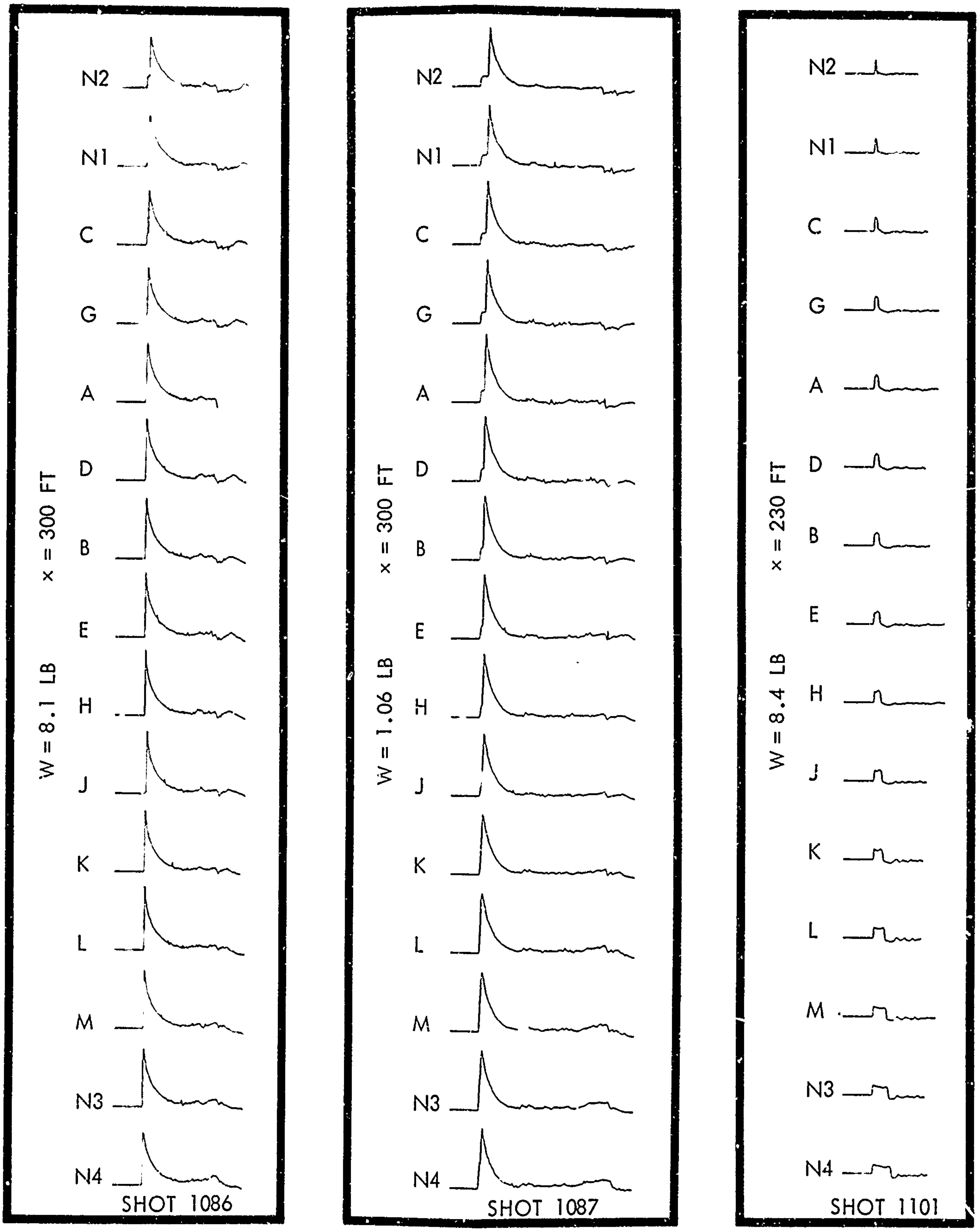


FIG. 4f REDUCED PRESSURE-TIME PLOTS FOR CHARC

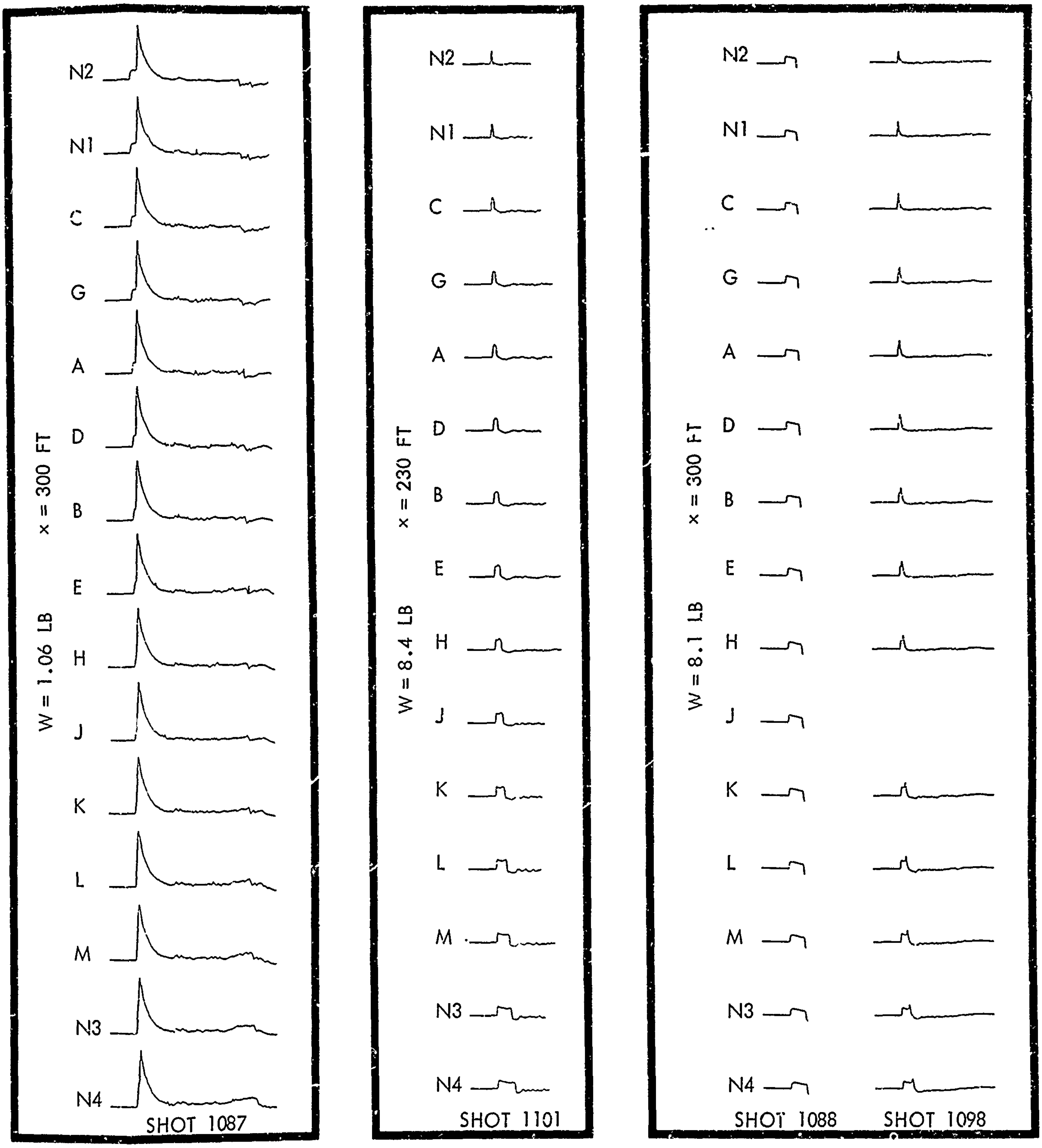


FIG. 4f REDUCED PRESSURE-TIME PLOTS FOR CHARGES FIRED AT 25-FT DEPTH

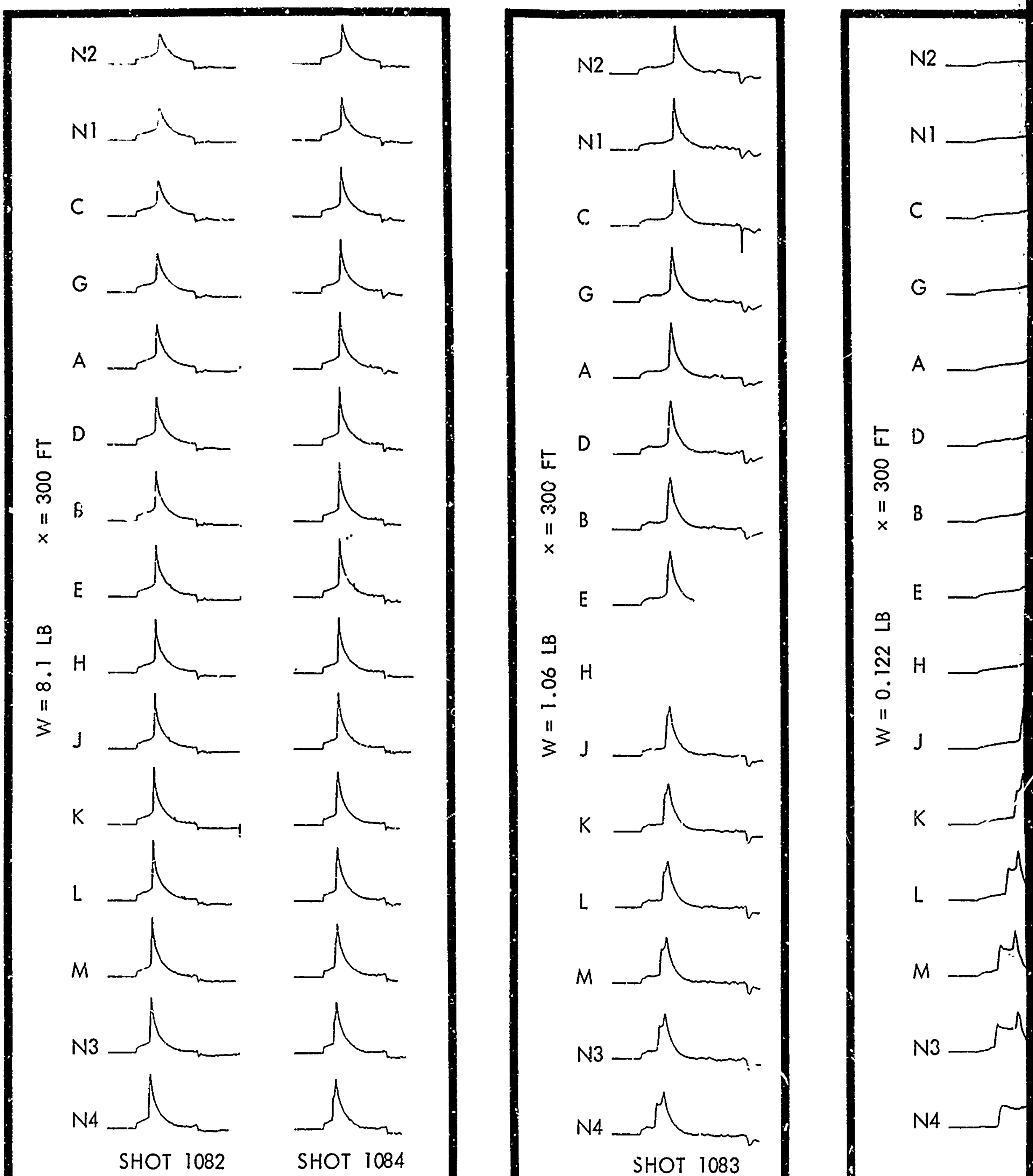


FIG. 4g REDUCED PRESSURE - TIME

A

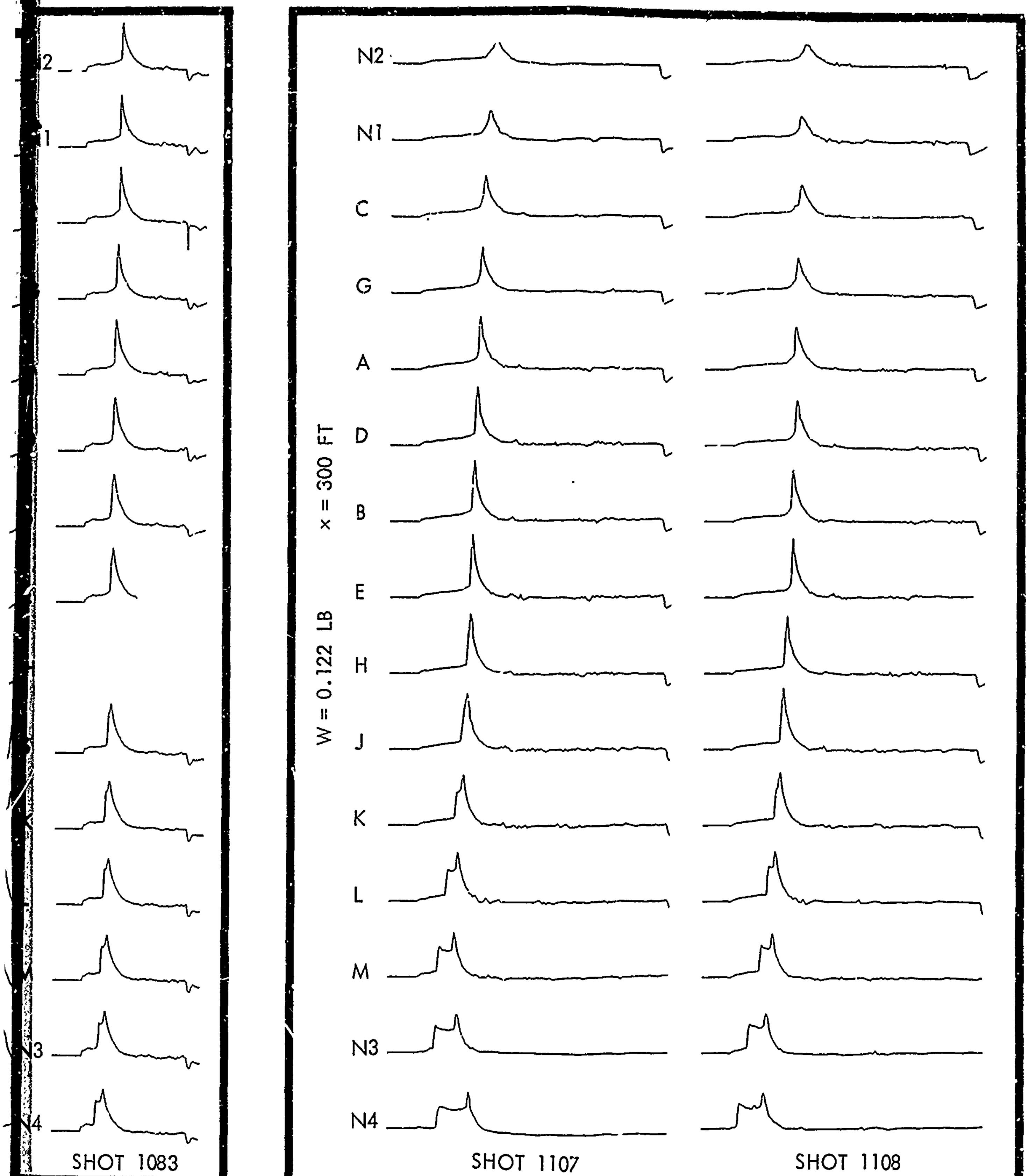


FIG. 4g REDUCED PRESSURE-TIME PLOTS FOR CHARGES FIRED AT 50-FT DEPTH

B

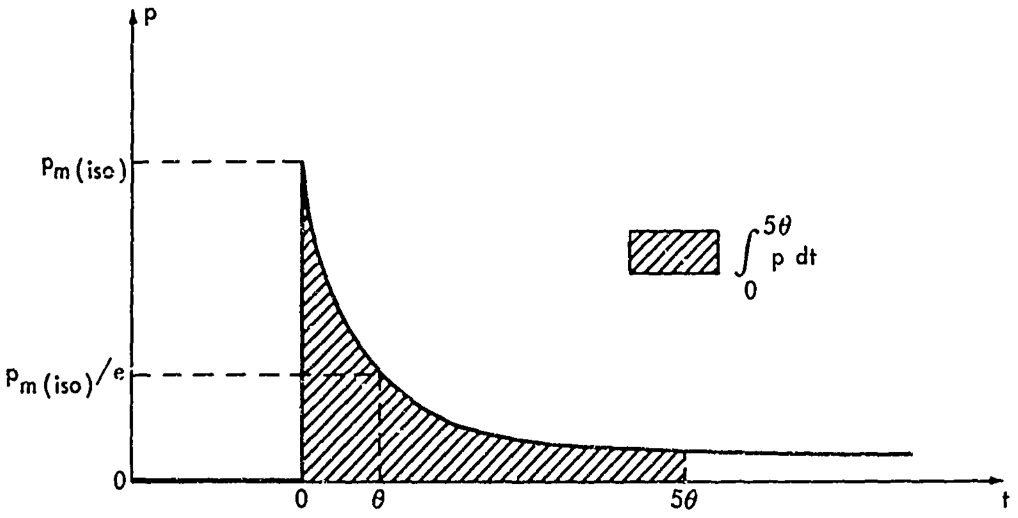


FIG. 5a EXPONENTIALLY DECAYING SHOCK WAVE PULSE IN ISOVELOCITY WATER

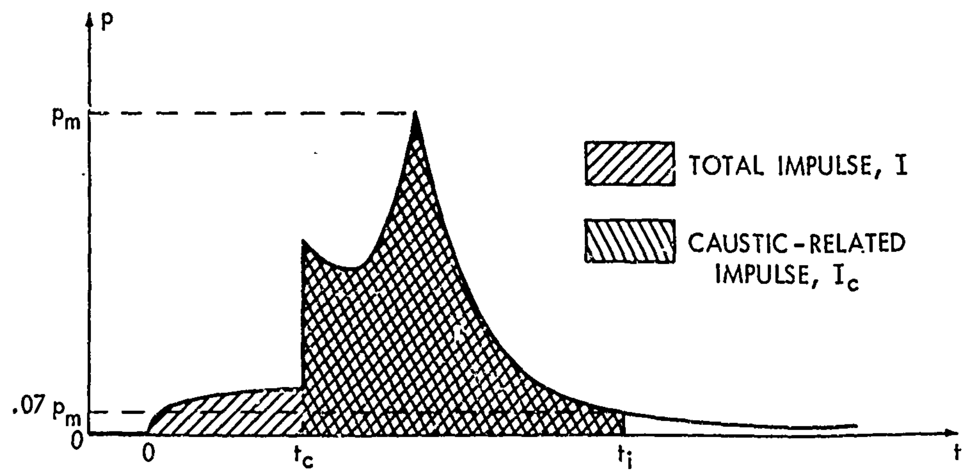


FIG. 5b A SAMPLE PRESSURE PULSE IN REFRACTIVE WATER

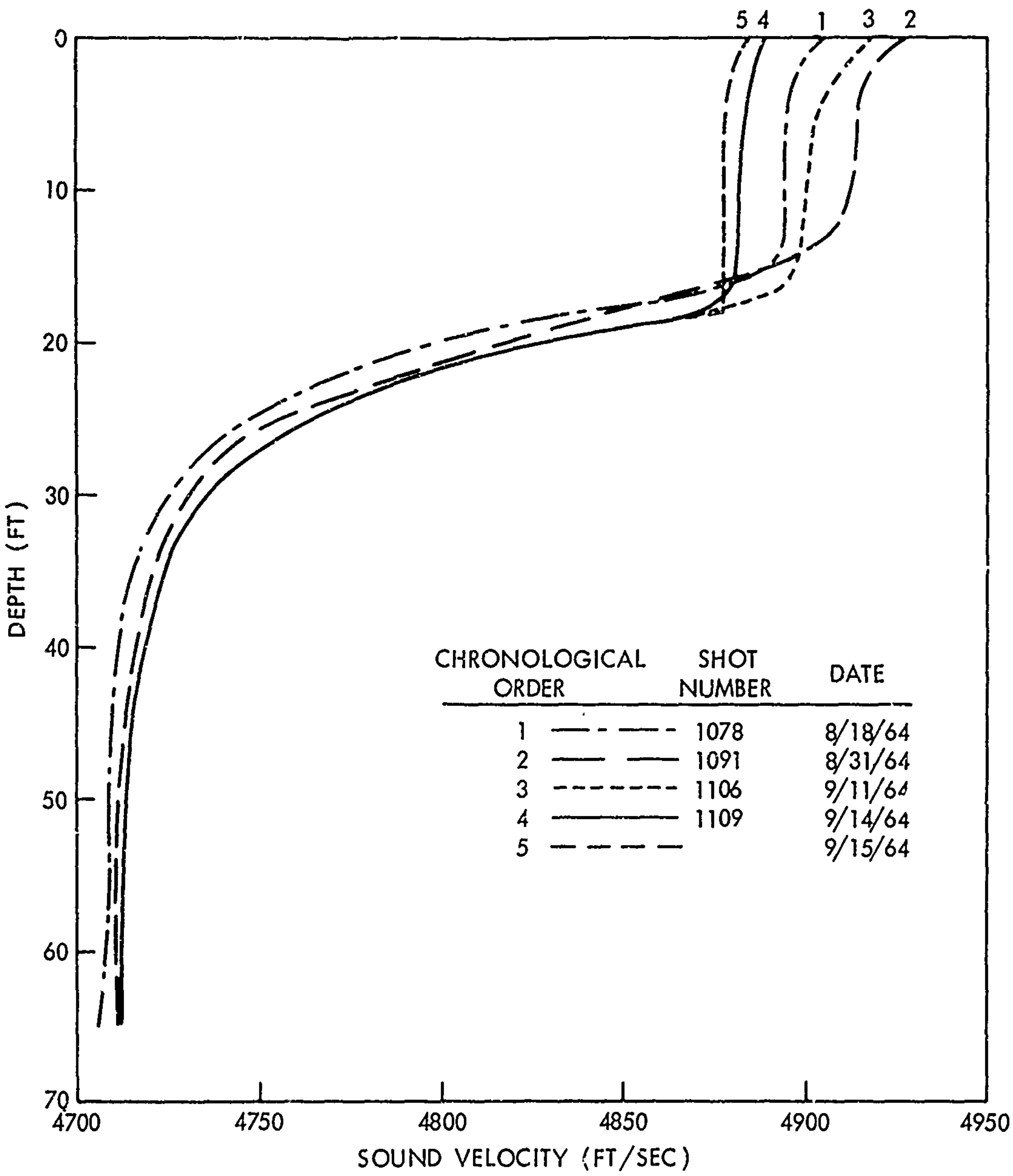


FIG. 6 REPRESENTATIVE SOUND VELOCITY PROFILES

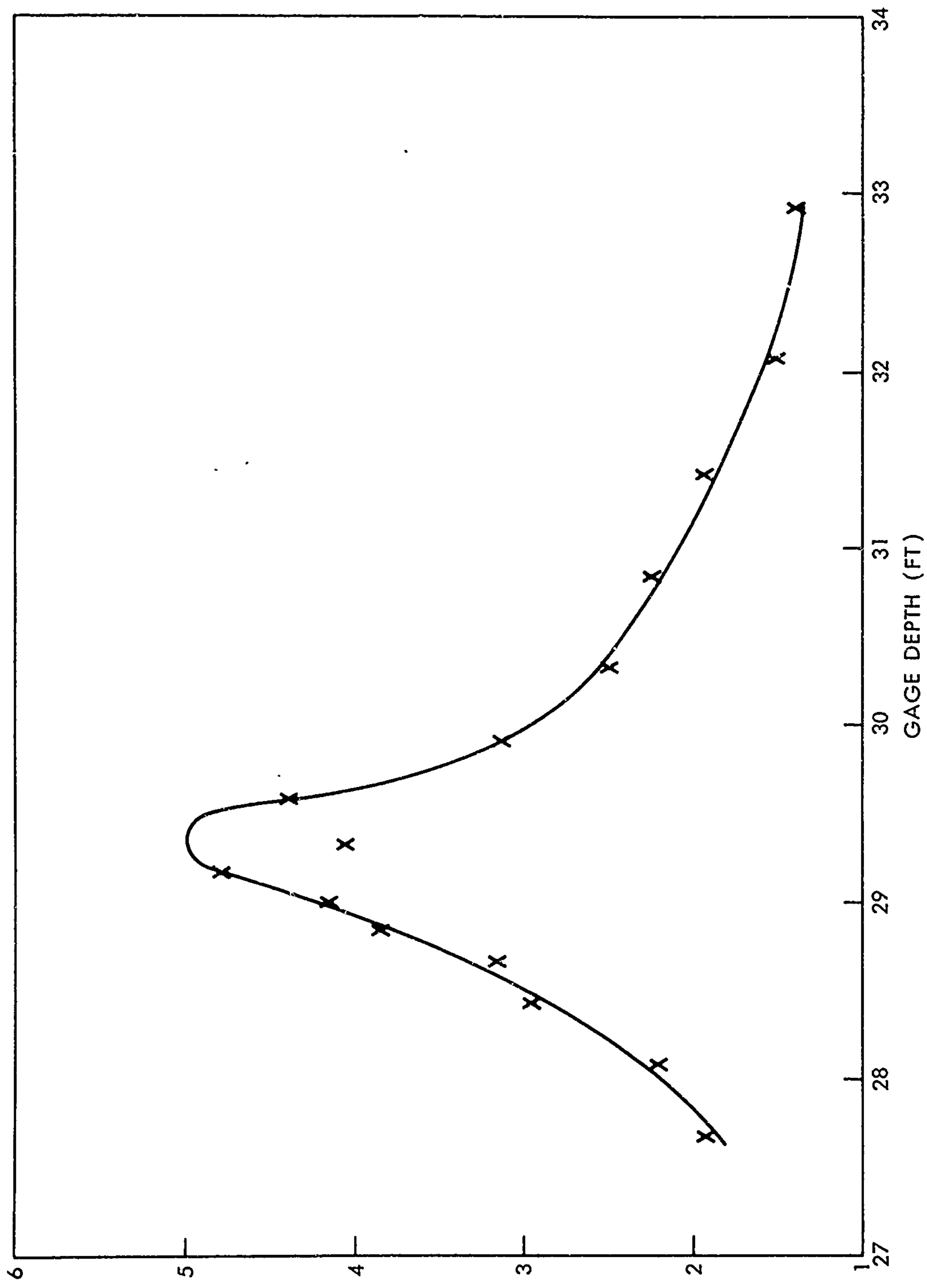


FIG. 7 PEAK PRESSURE AMPLIFICATION FACTOR VS GAGE DEPTH FOR SHOT 1104

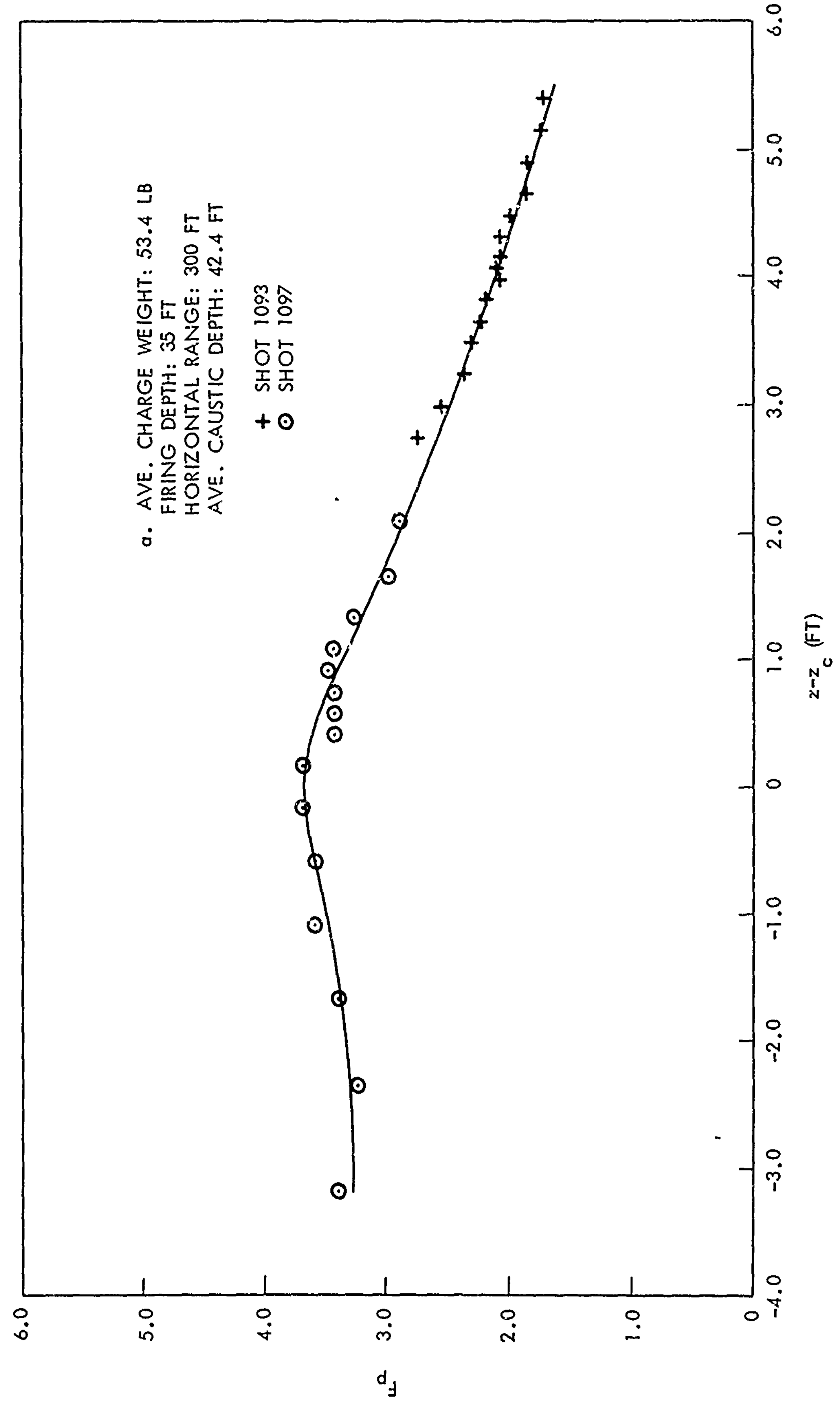


FIG. 8a PEAK PRESSURE AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC

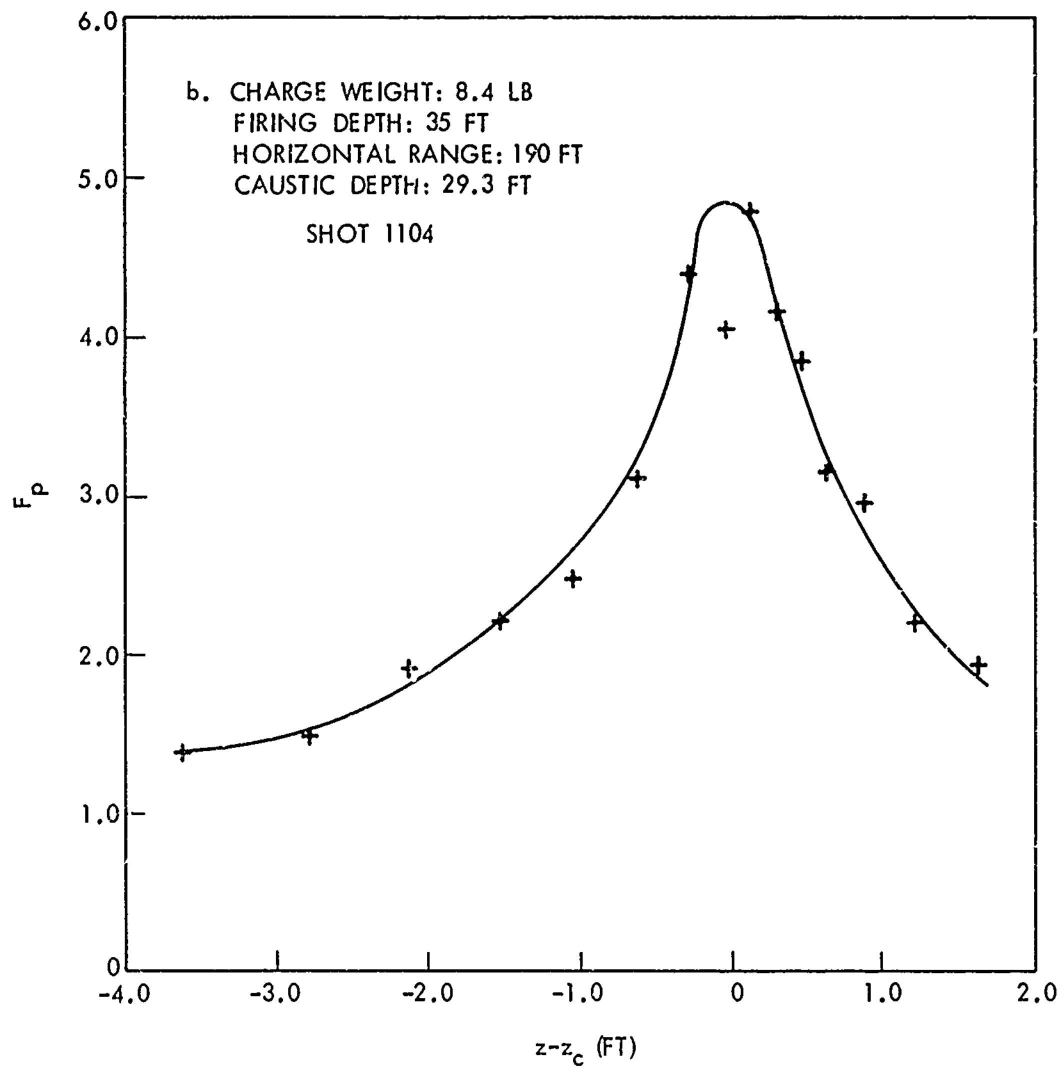


FIG. 8b PEAK PRESSURE AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC

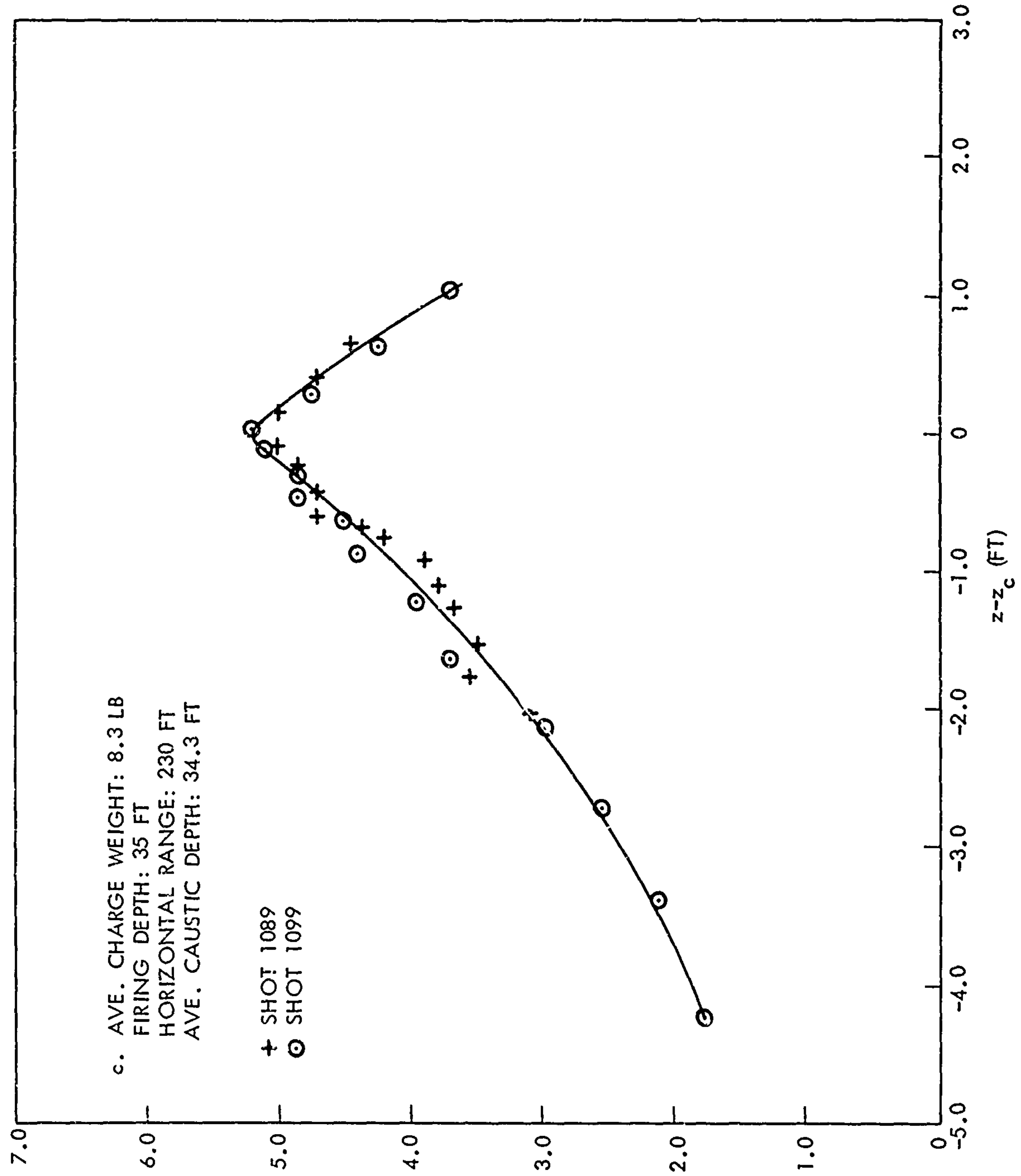


FIG. 8c PEAK PRESSURE AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC

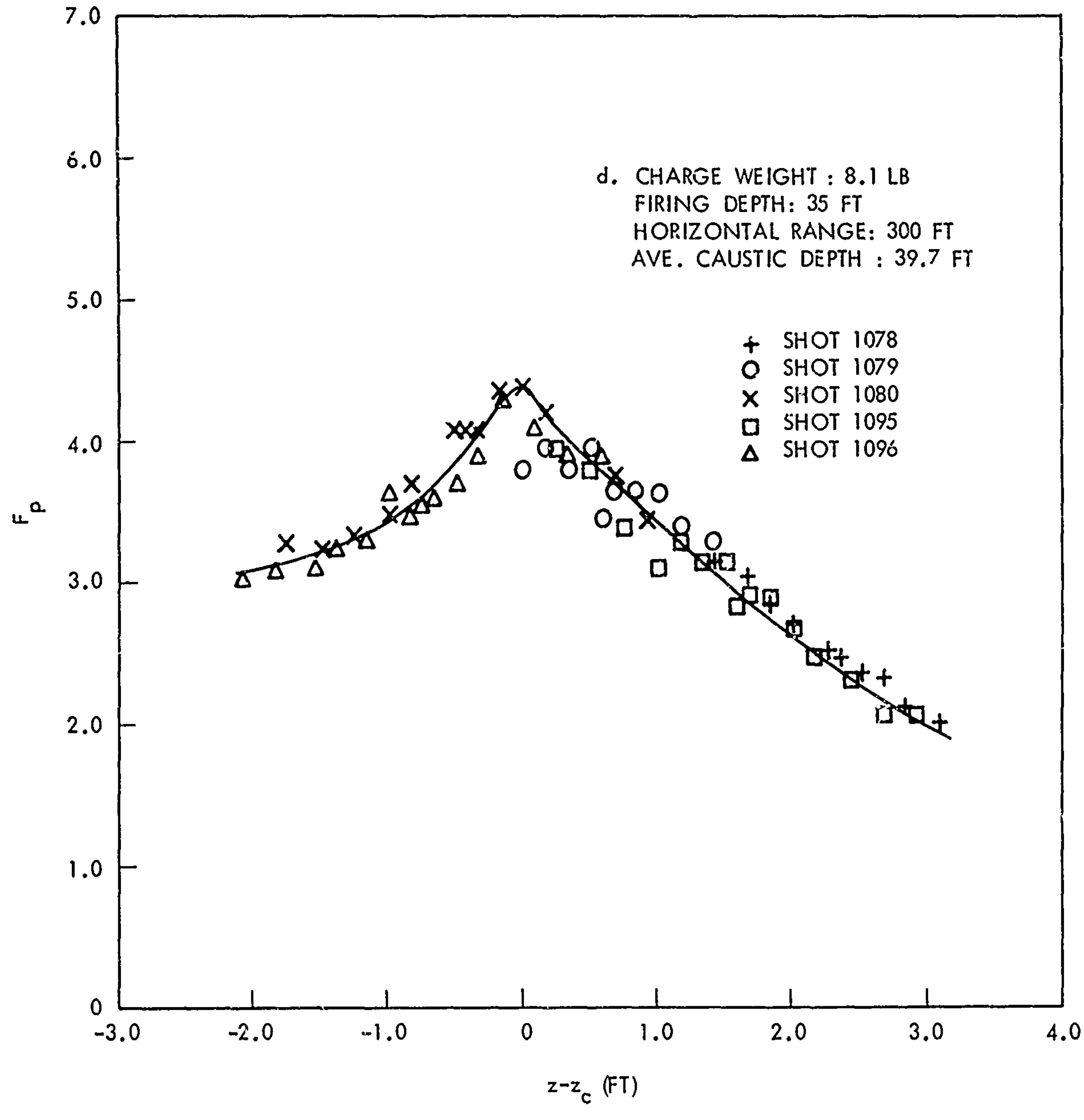


FIG. 8d PEAK PRESSURE AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC

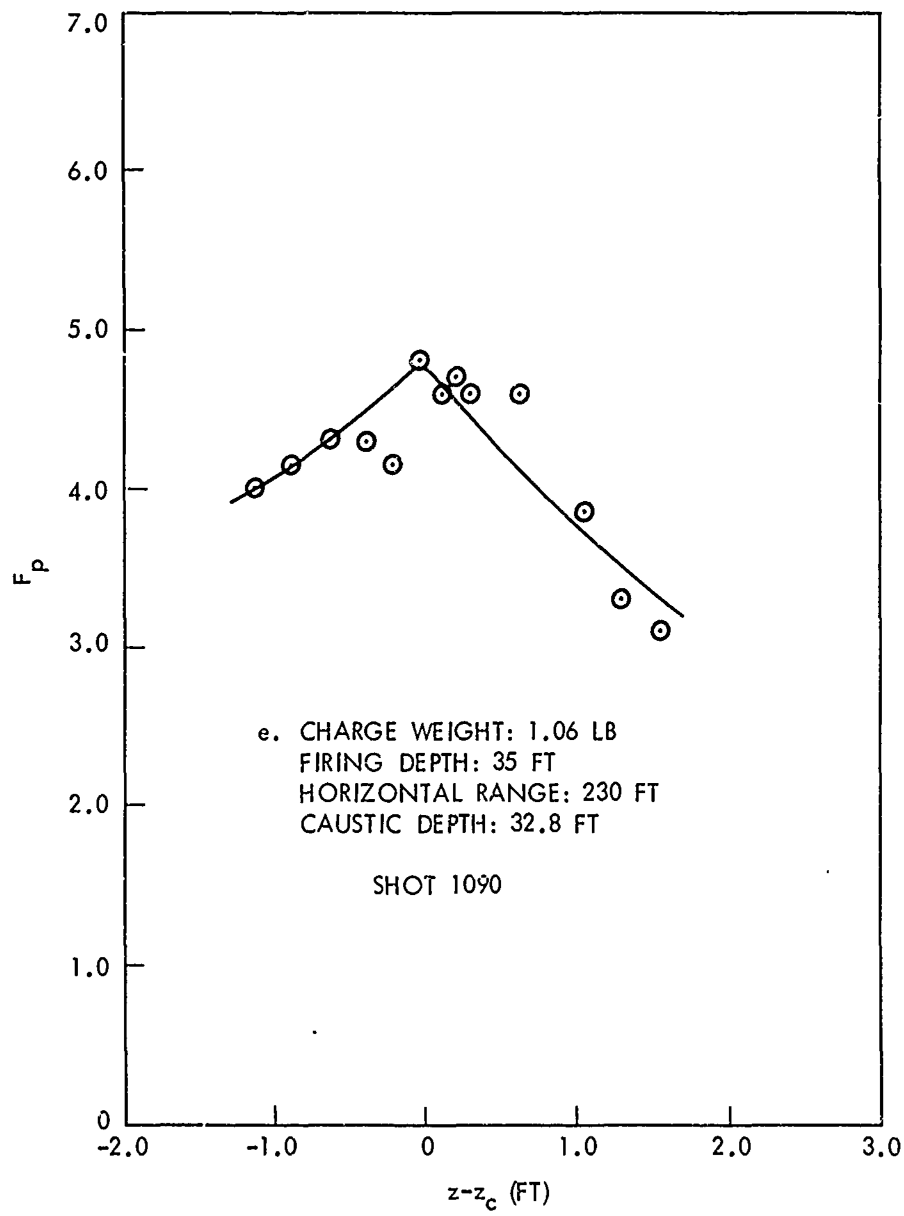


FIG. 8e PEAK PRESSURE AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC

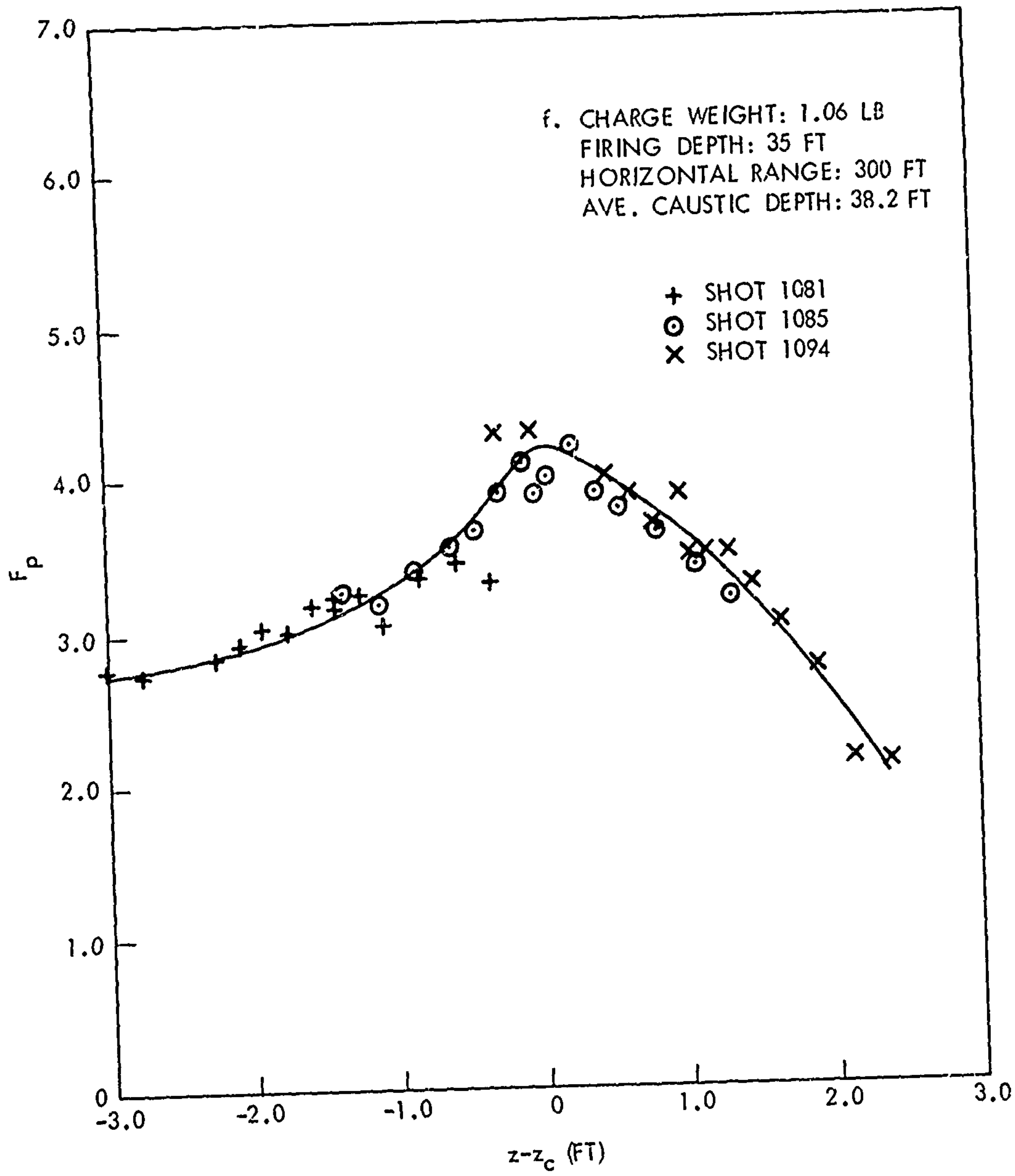


FIG. 8f PEAK PRESSURE AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC

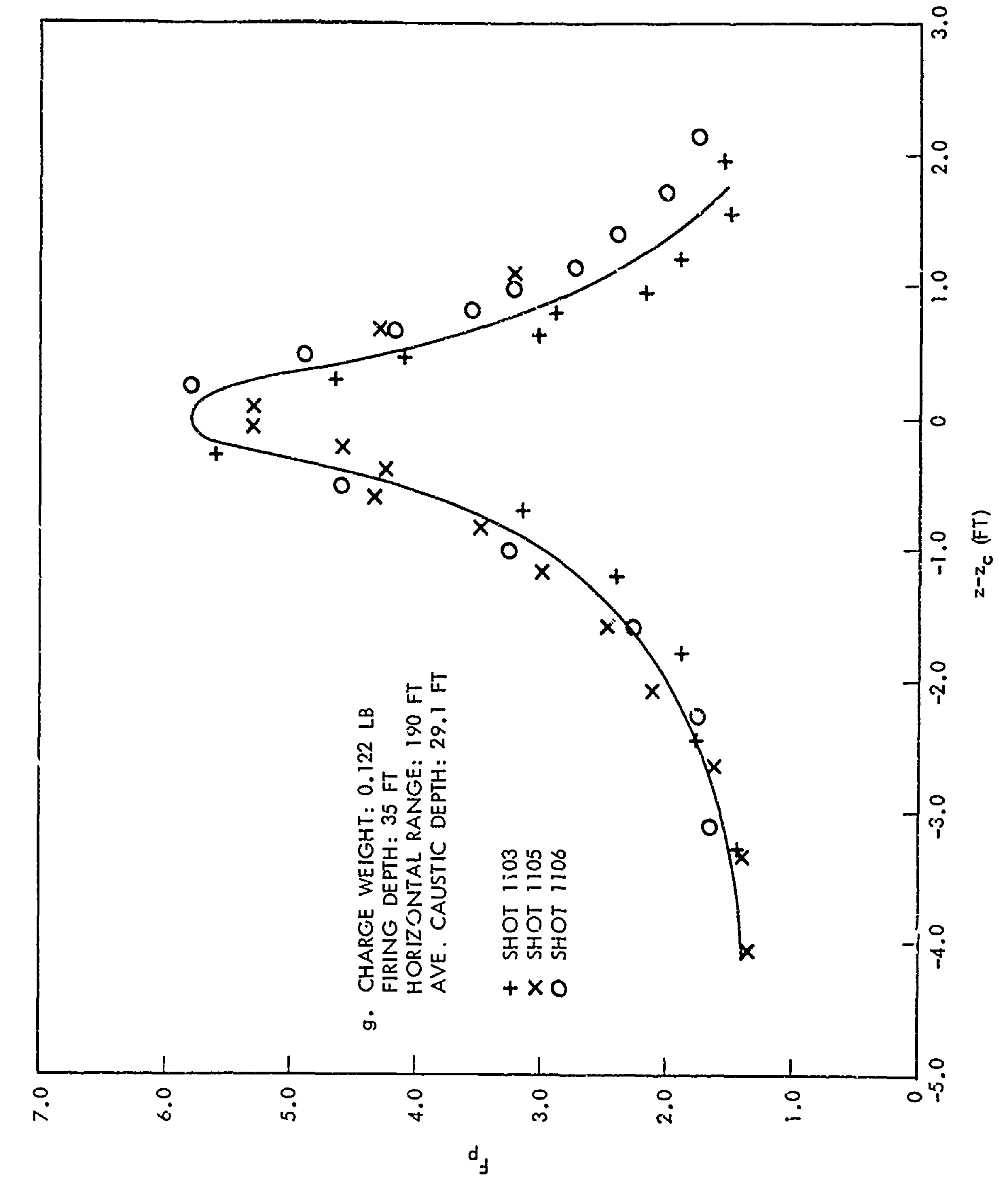


FIG. 8g PEAK PRESSURE AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC

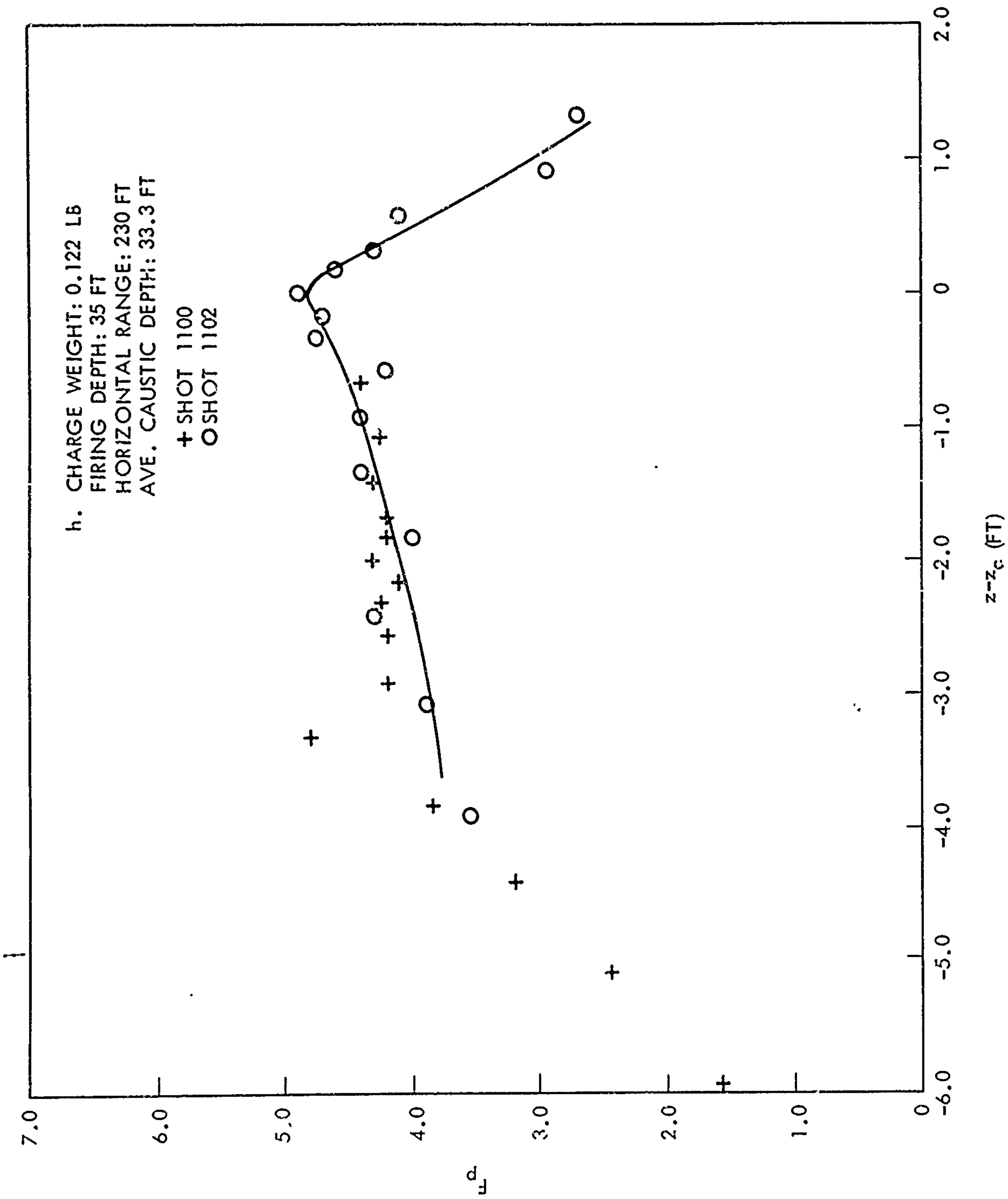


FIG. 8h PEAK PRESSURE AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC

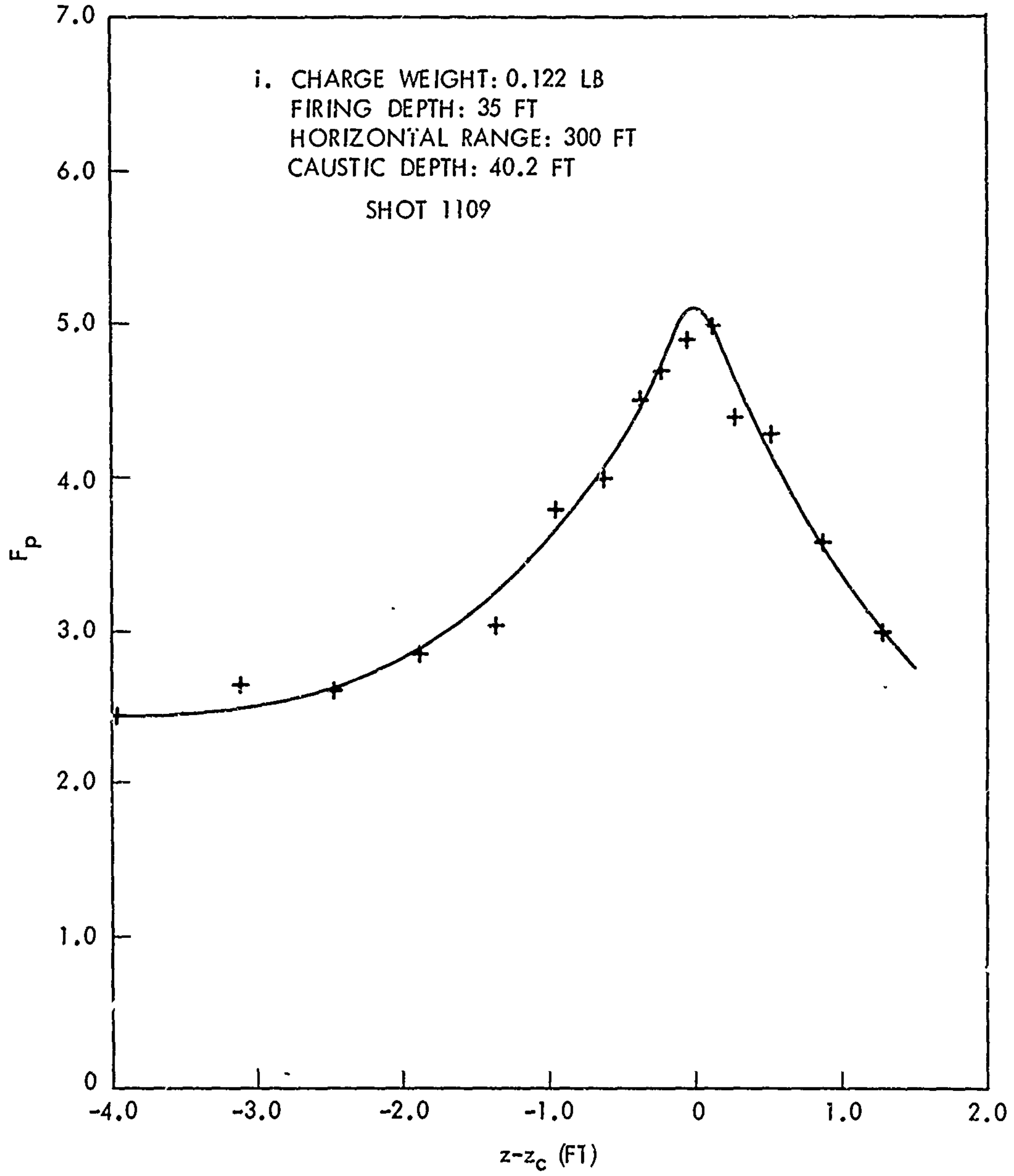


FIG. 8i PEAK PRESSURE AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC

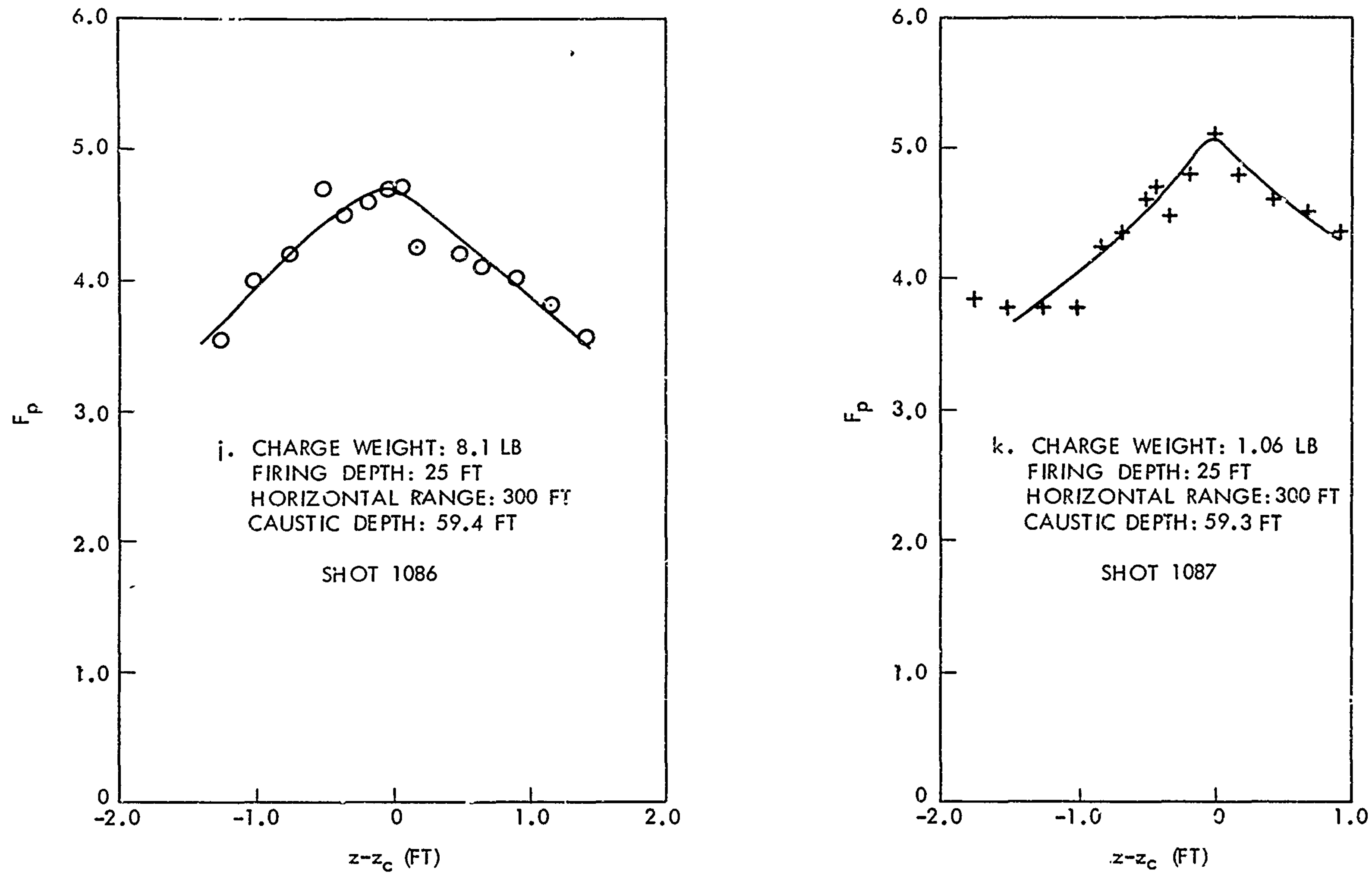


FIG. 8j & k PEAK PRESSURE AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC

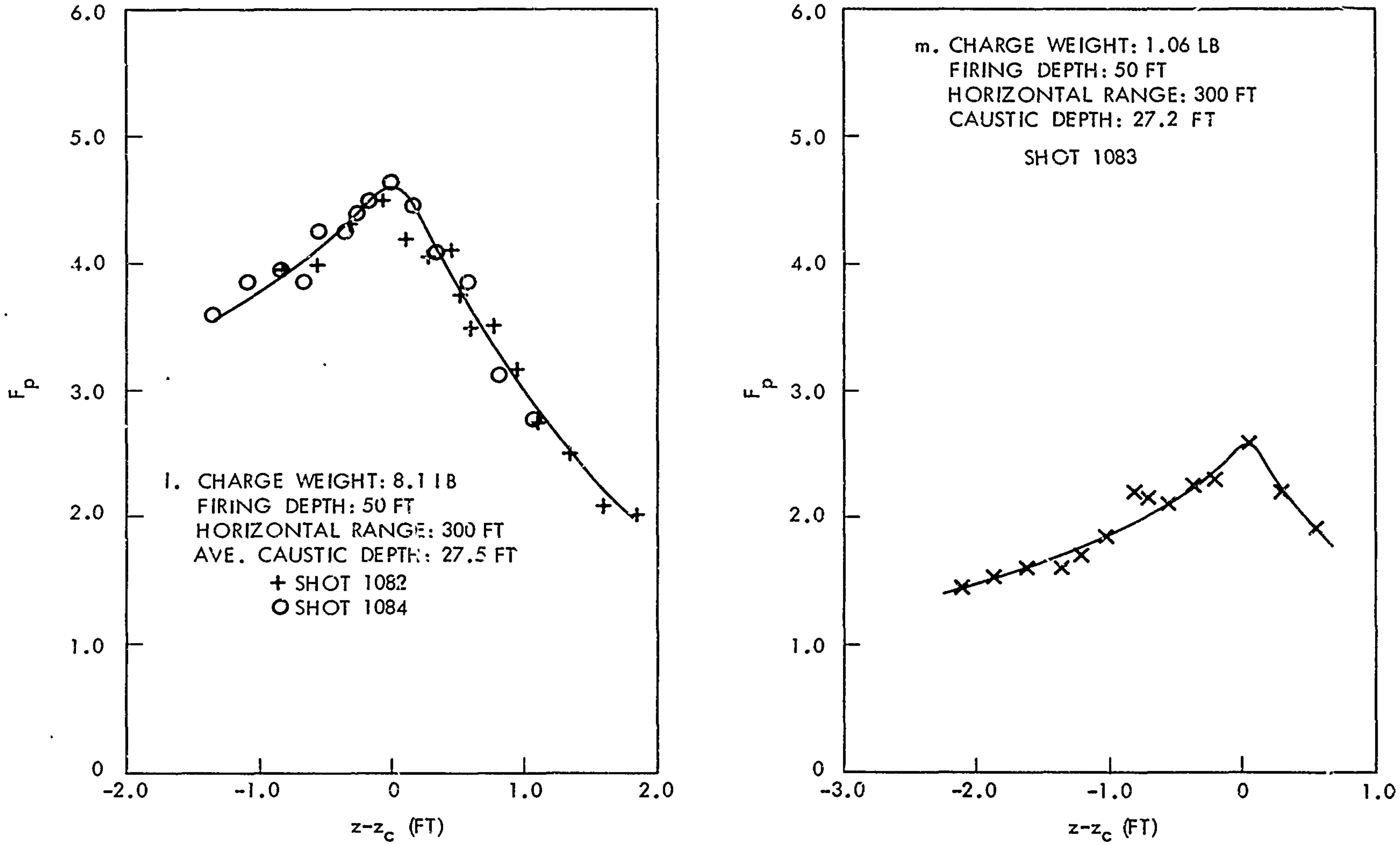


FIG. 8 l&m PEAK PRESSURE AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC

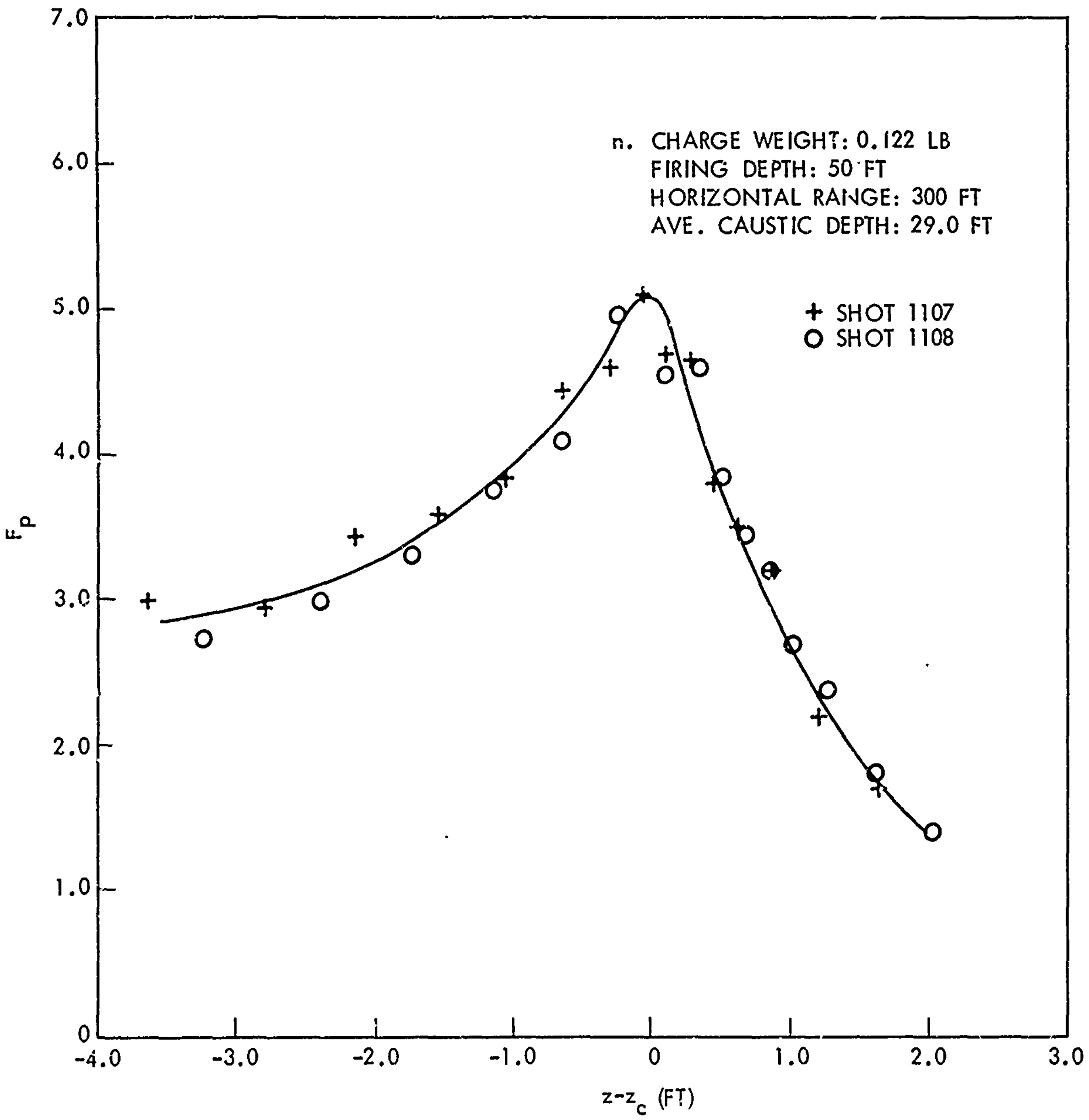


FIG. 8n PEAK PRESSURE AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC

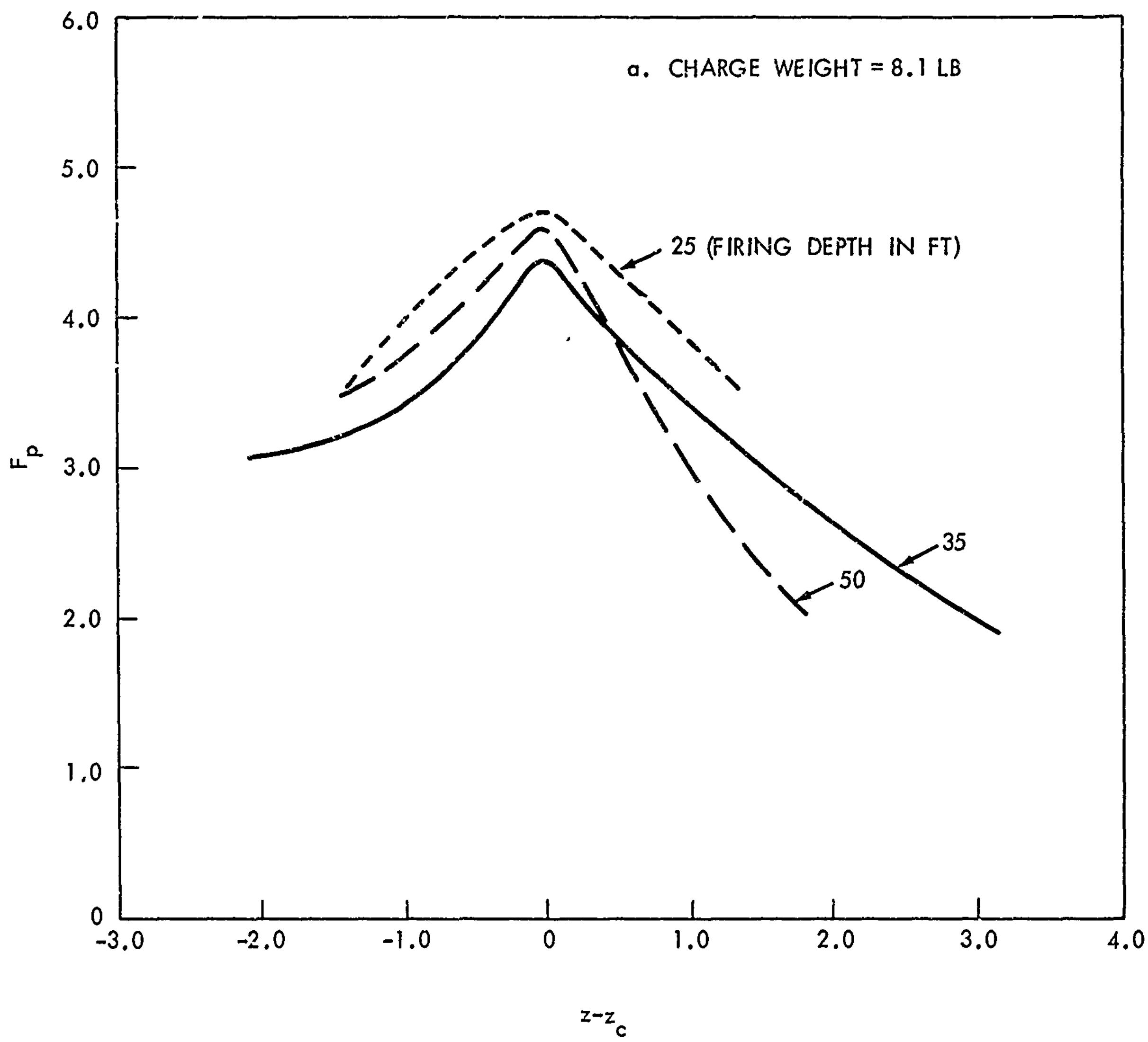


FIG. 9a PEAK PRESSURE AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC: VARIATION WITH FIRING DEPTH AT HORIZONTAL RANGE OF 300 FT

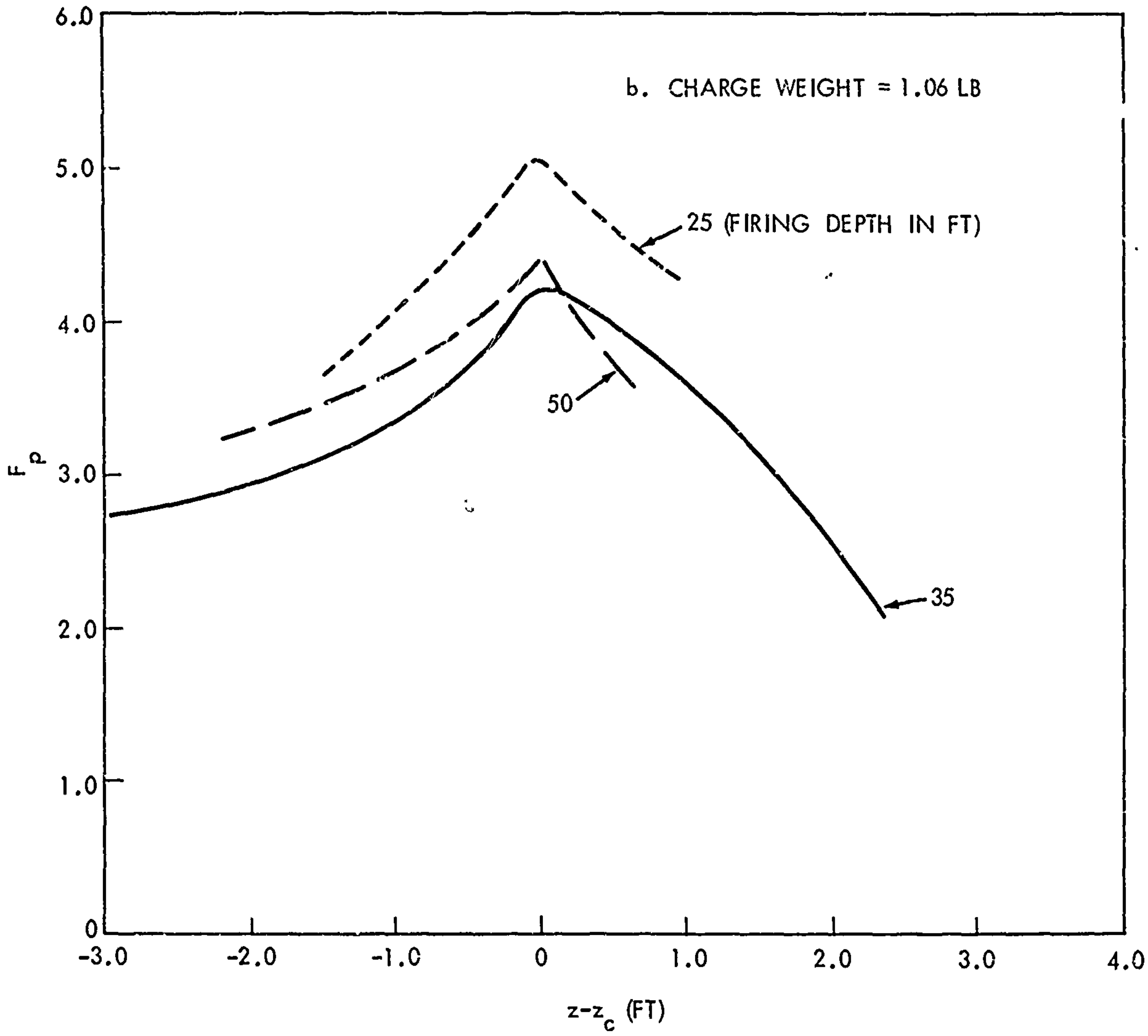


FIG. 9b PEAK PRESSURE AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC: VARIATION WITH FIRING DEPTH AT HORIZONTAL RANGE OF 300 FT

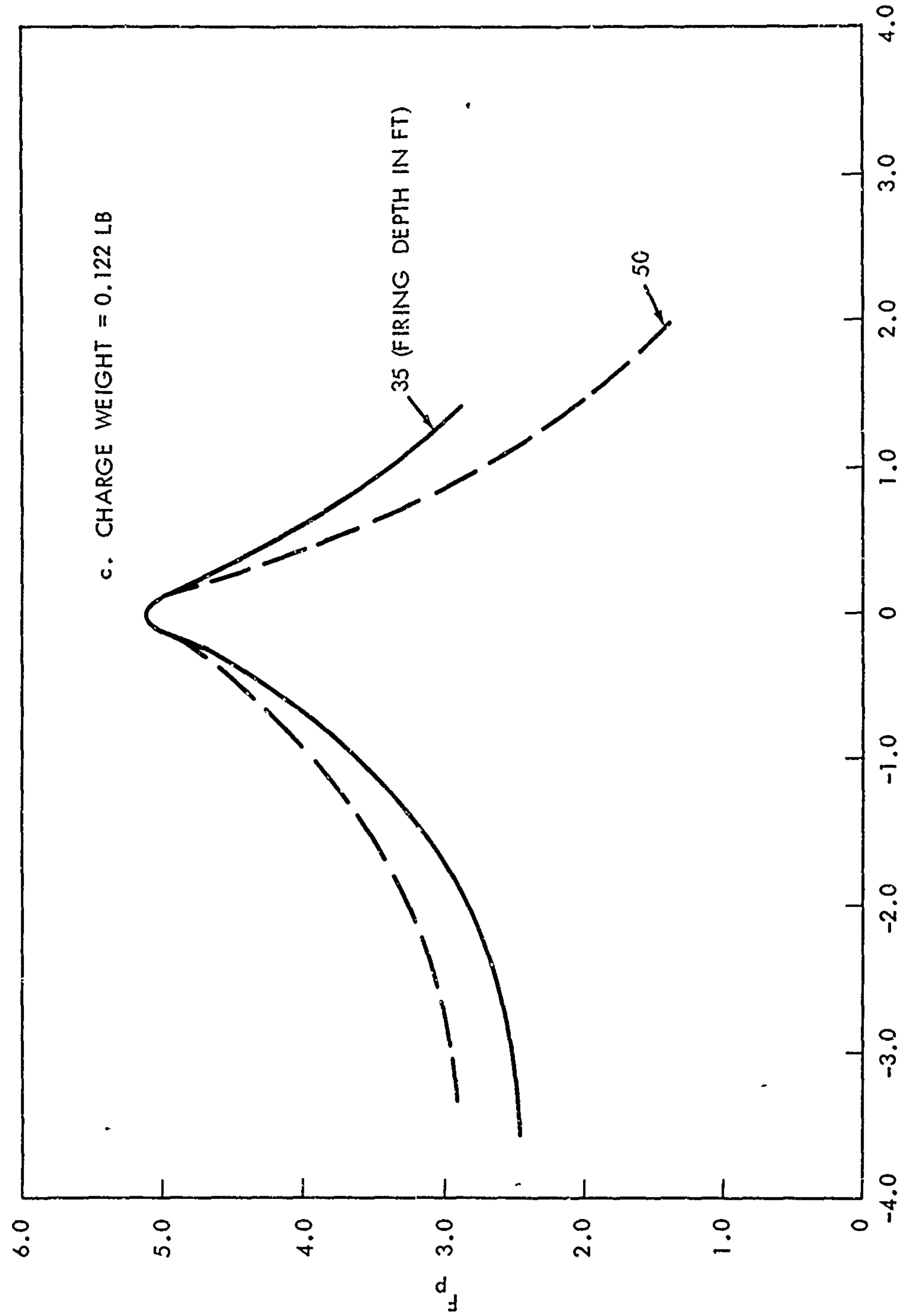


FIG. 9c PEAK PRESSURE AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC: VARIATION WITH FIRING DEPTH AT HORIZONTAL RANGE OF 300 FT

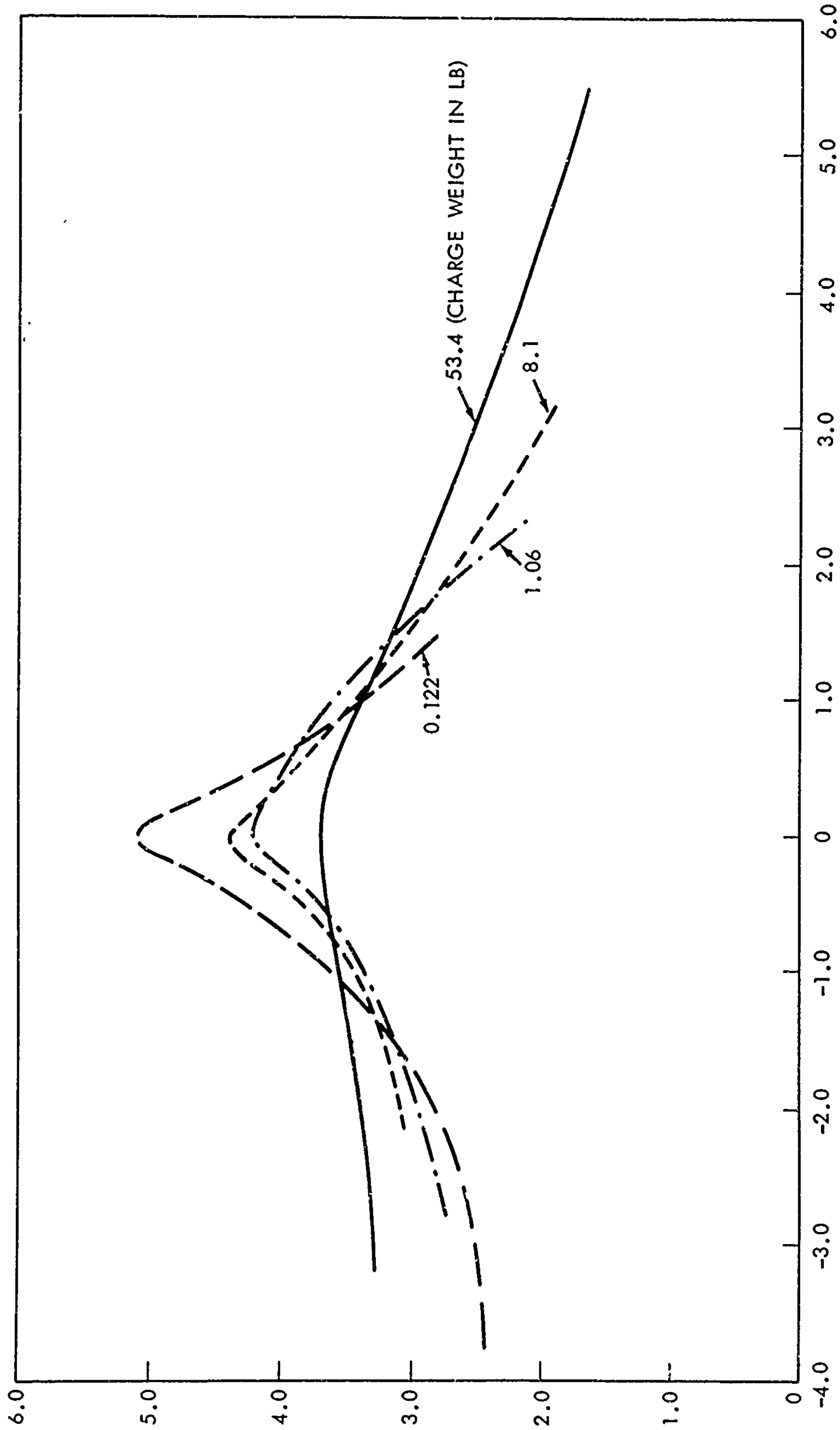


FIG. 10a PEAK PRESSURE AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC: VARIATION WITH CHARGE WEIGHT AT 300-FT HORIZONTAL RANGE AND 35-FT FIRING DEPTH

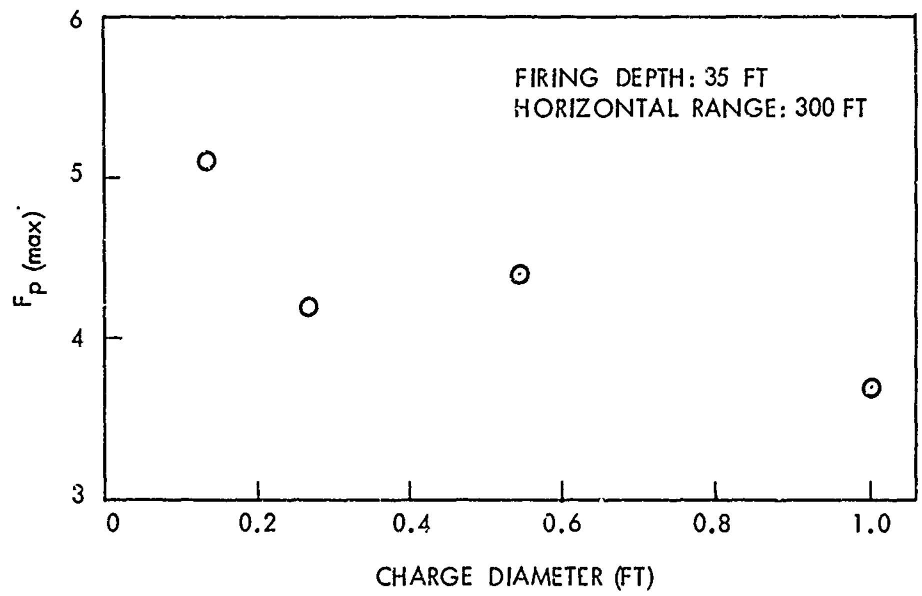


FIG. 10b MAXIMUM F_p VS CHARGE DIAMETER

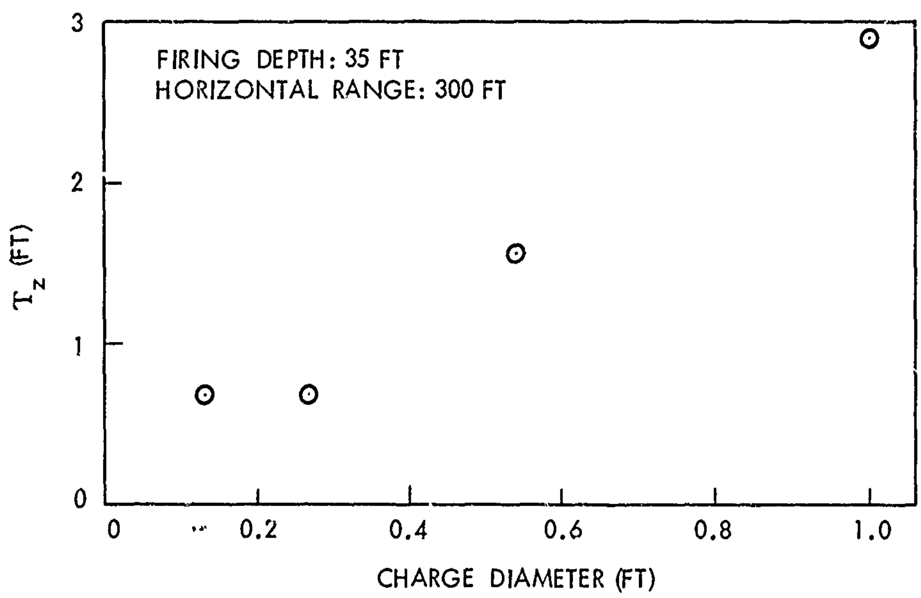


FIG. 10c CAUSTIC THICKNESS VS CHARGE DIAMETER

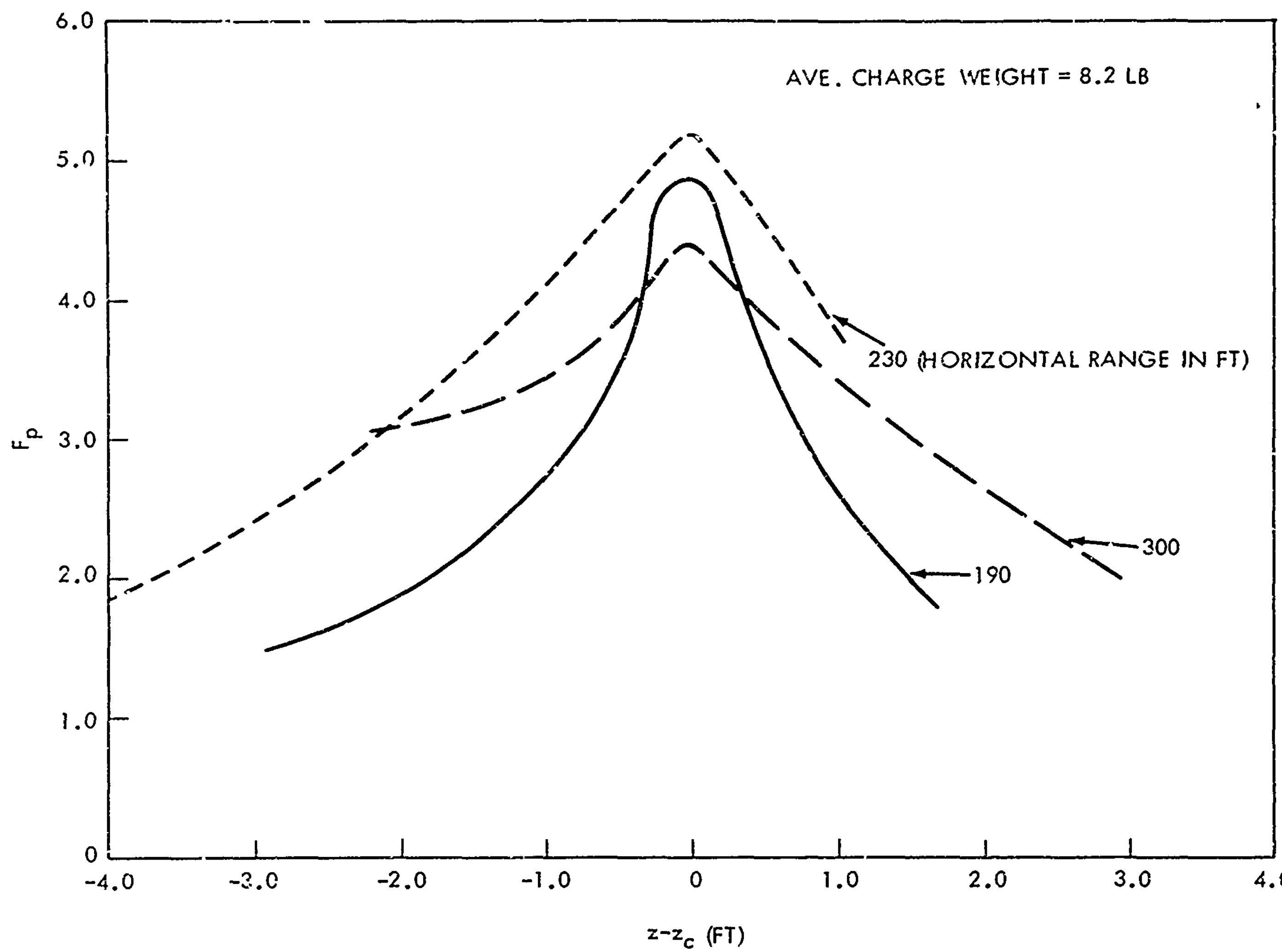


FIG. 11a PEAK PRESSURE AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC: VARIATION WITH HORIZONTAL RANGE AT 35-FT FIRING DEPTH

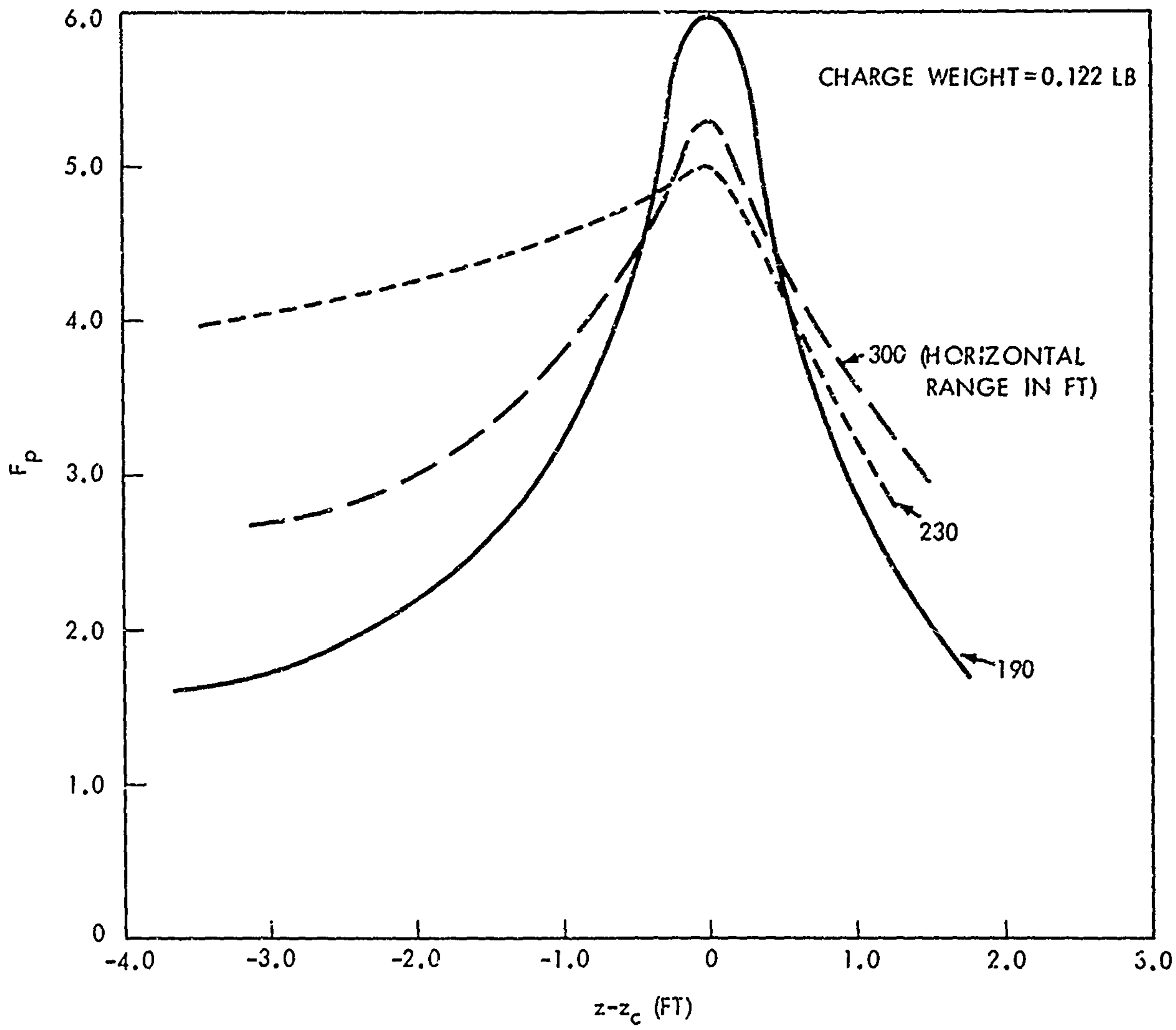


FIG. 11b PEAK PRESSURE AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC: VARIATION WITH HORIZONTAL RANGE AT 35-FT FIRING DEPTH

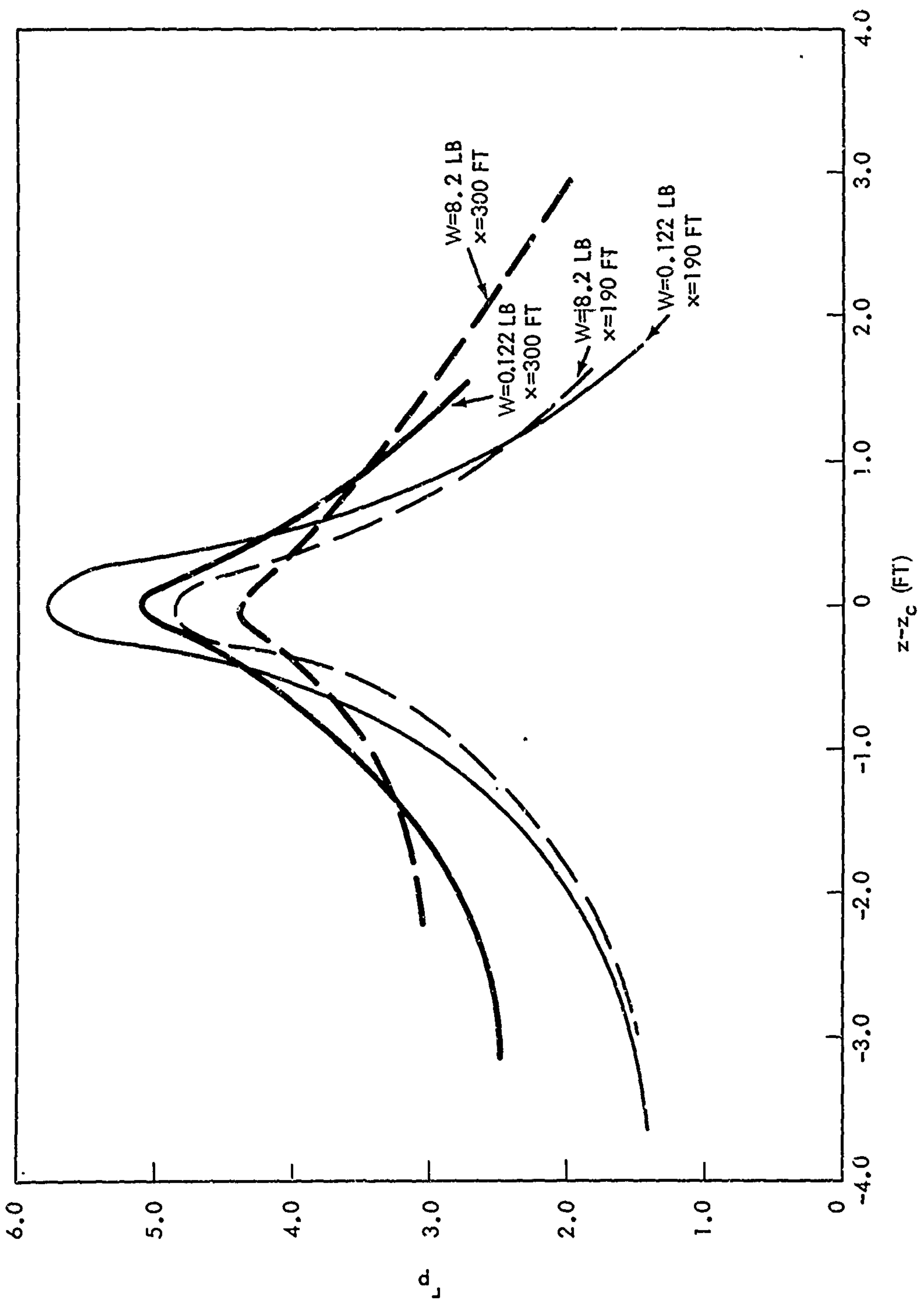


FIG. 11c PEAK PRESSURE AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC: EFFECT OF VARYING RANGE FOR TWO CHARGE SIZES AT 35-FT FIRING DEPTH

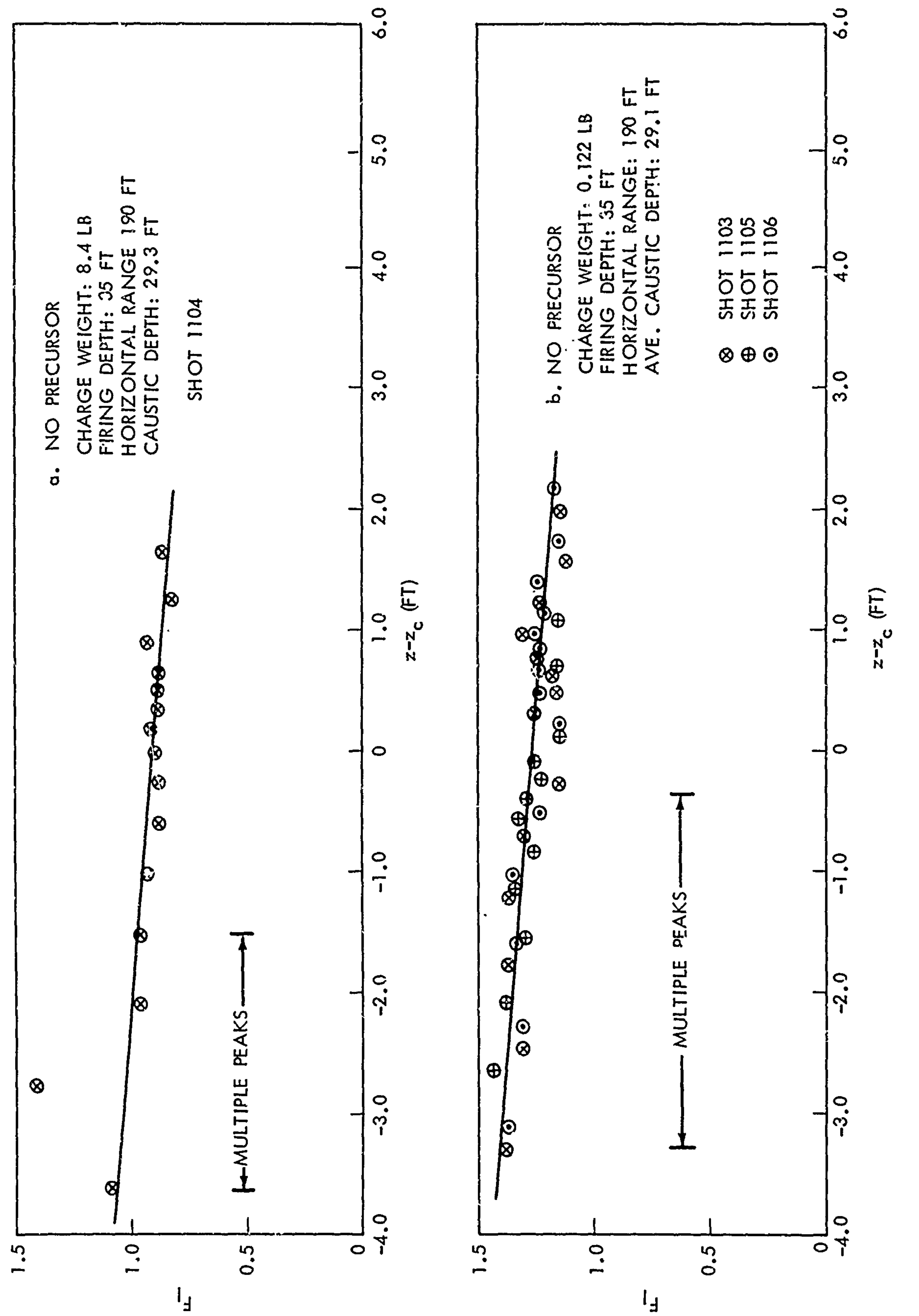


FIG. 12 a&b IMPULSE AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC

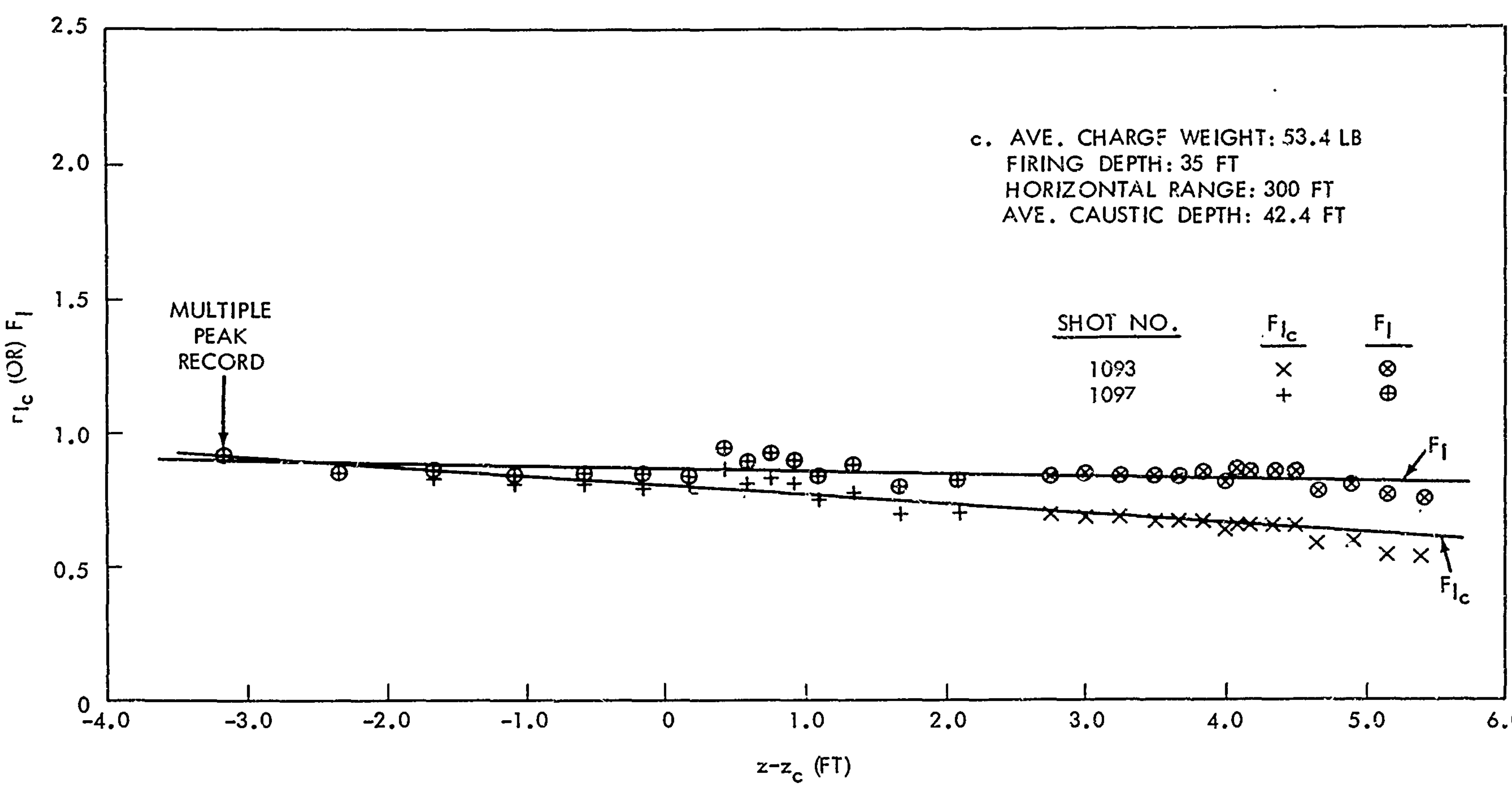


FIG. 12c IMPULSE AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC

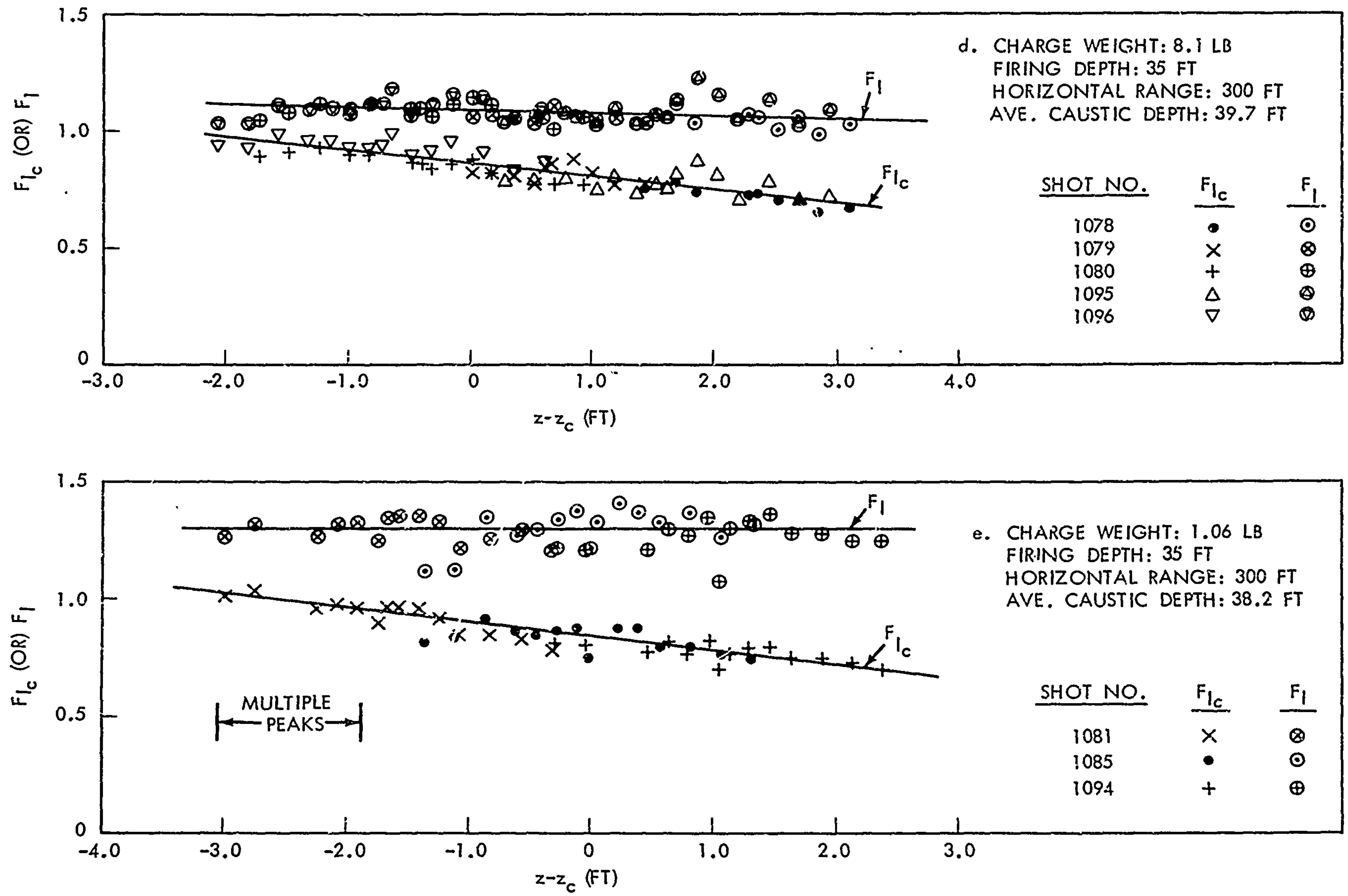


FIG. 12 d&e IMPULSE AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC

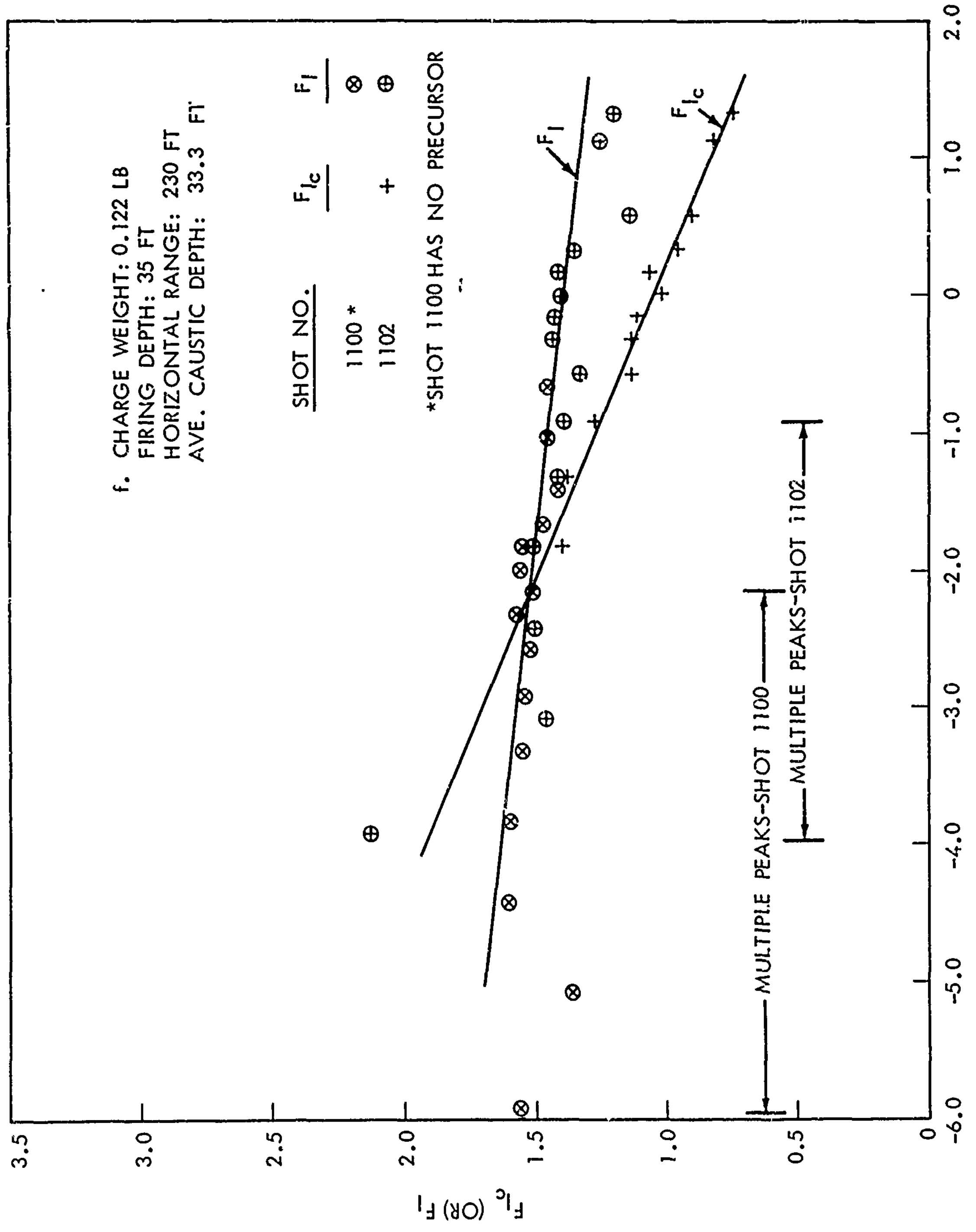


FIG. 12f IMPULSE AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC

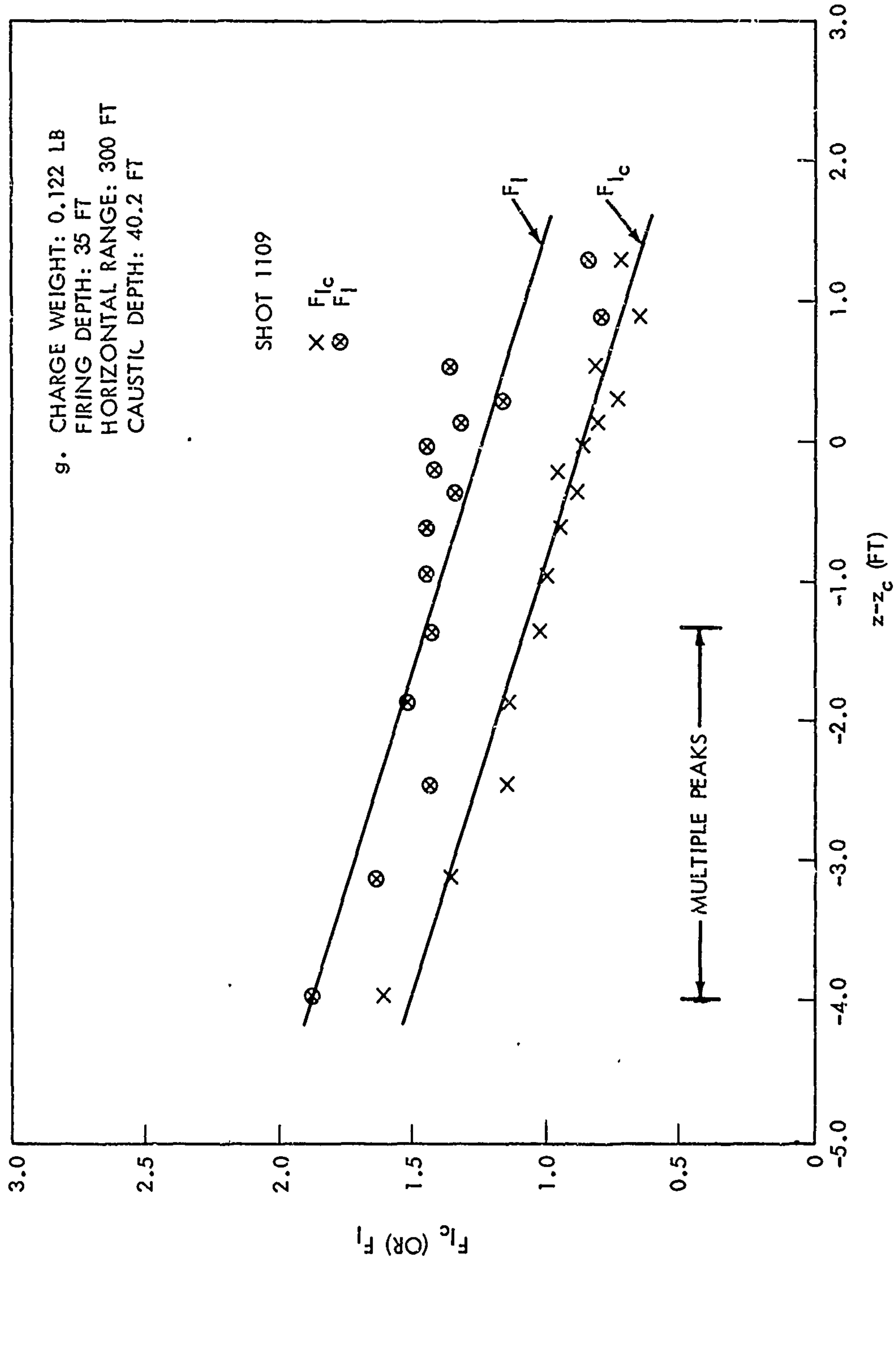


FIG. 12g IMPULSE AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC

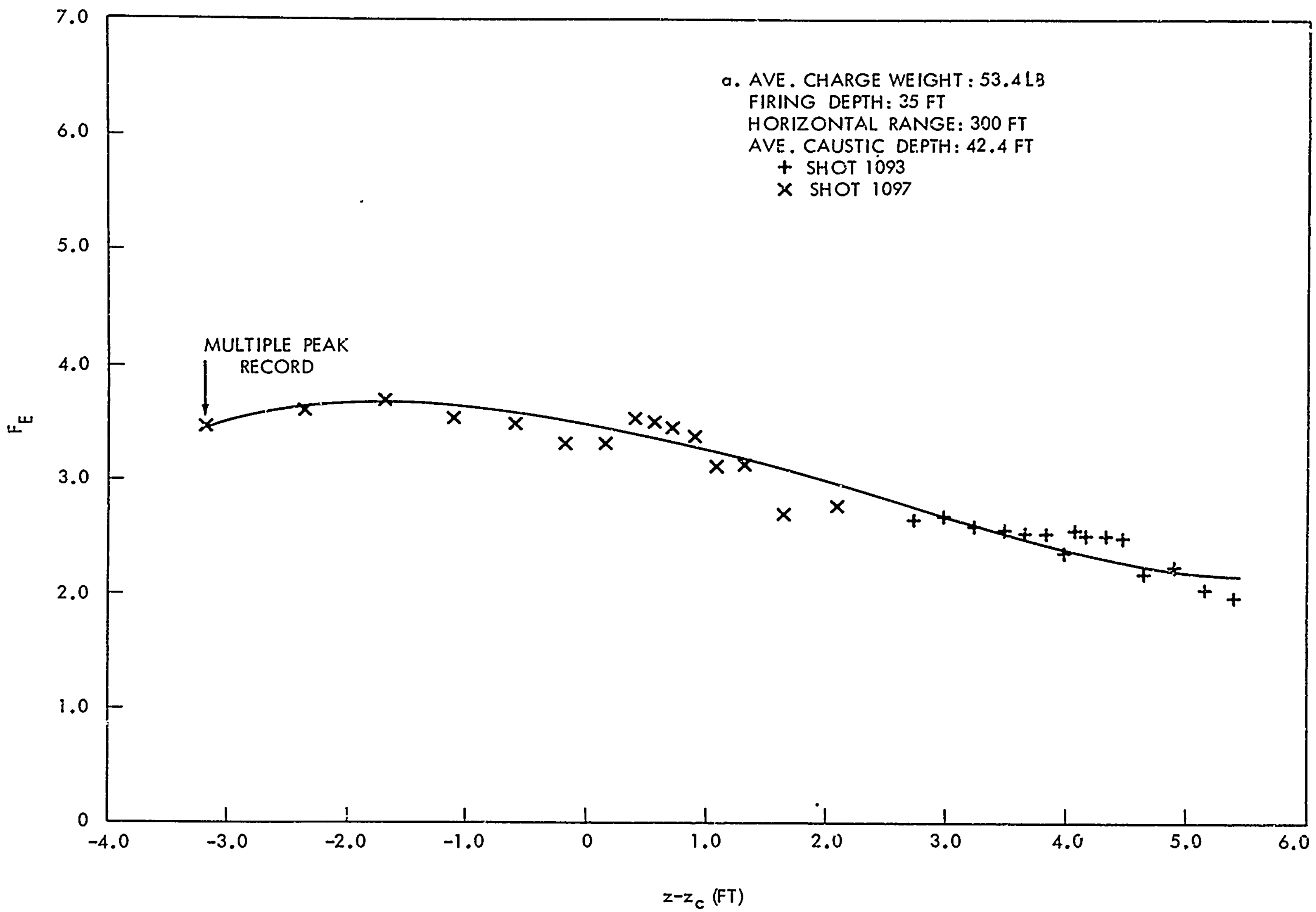


FIG. 13a ENERGY AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC

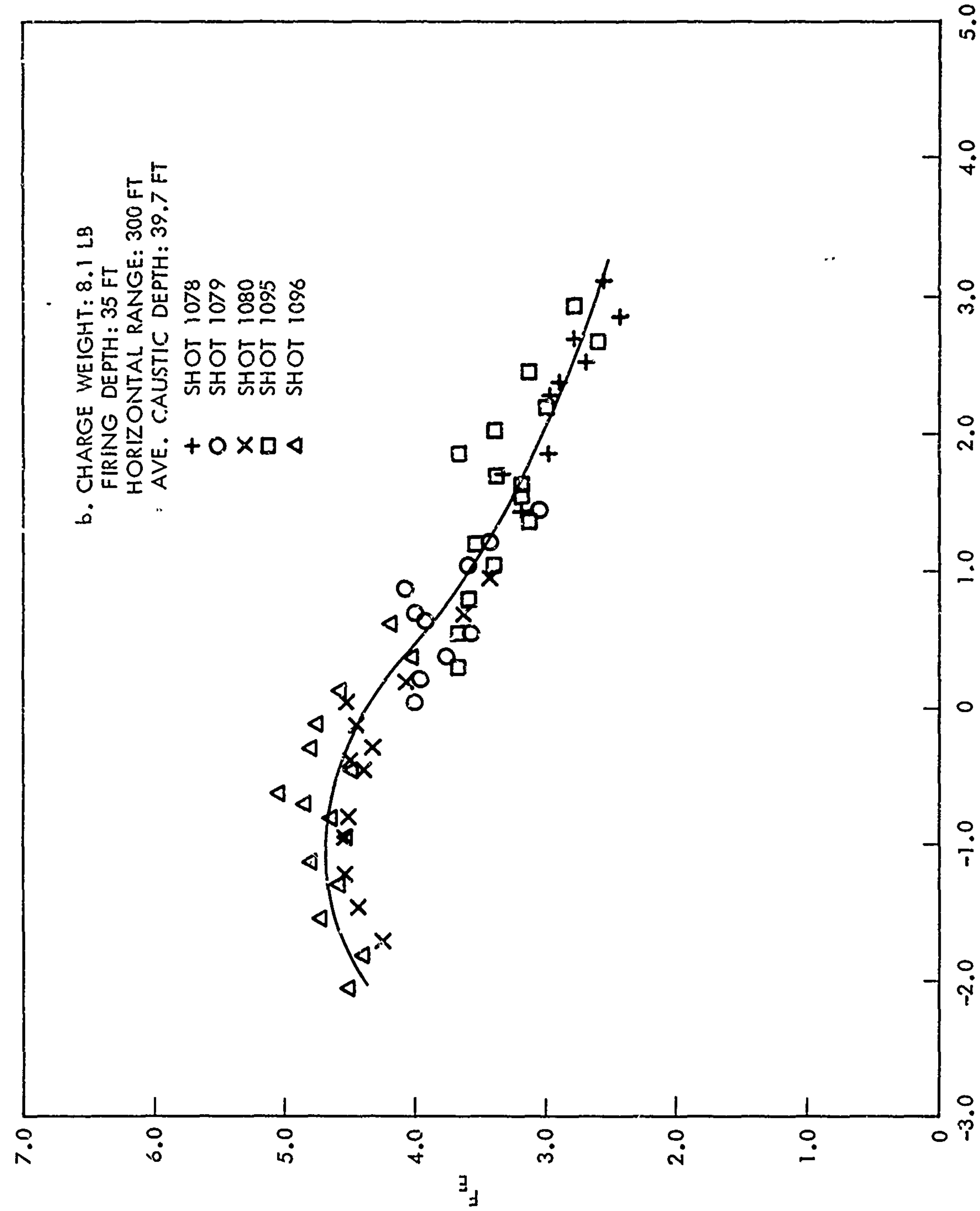


FIG. 13b ENERGY AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC

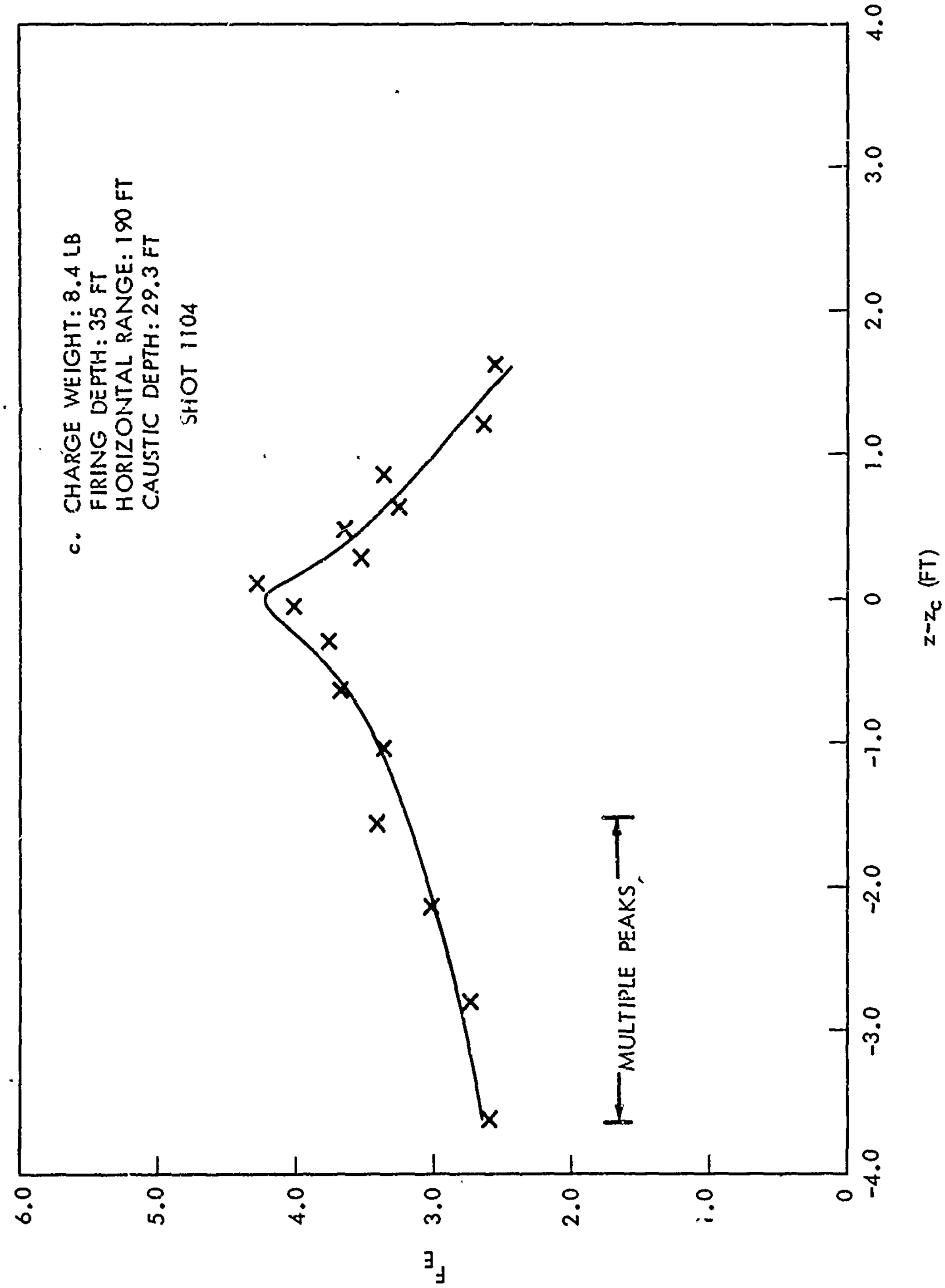


FIG. 13c ENERGY AMPLITUDE FACTOR VS VERTICAL DISTANCE FROM CAUSTIC

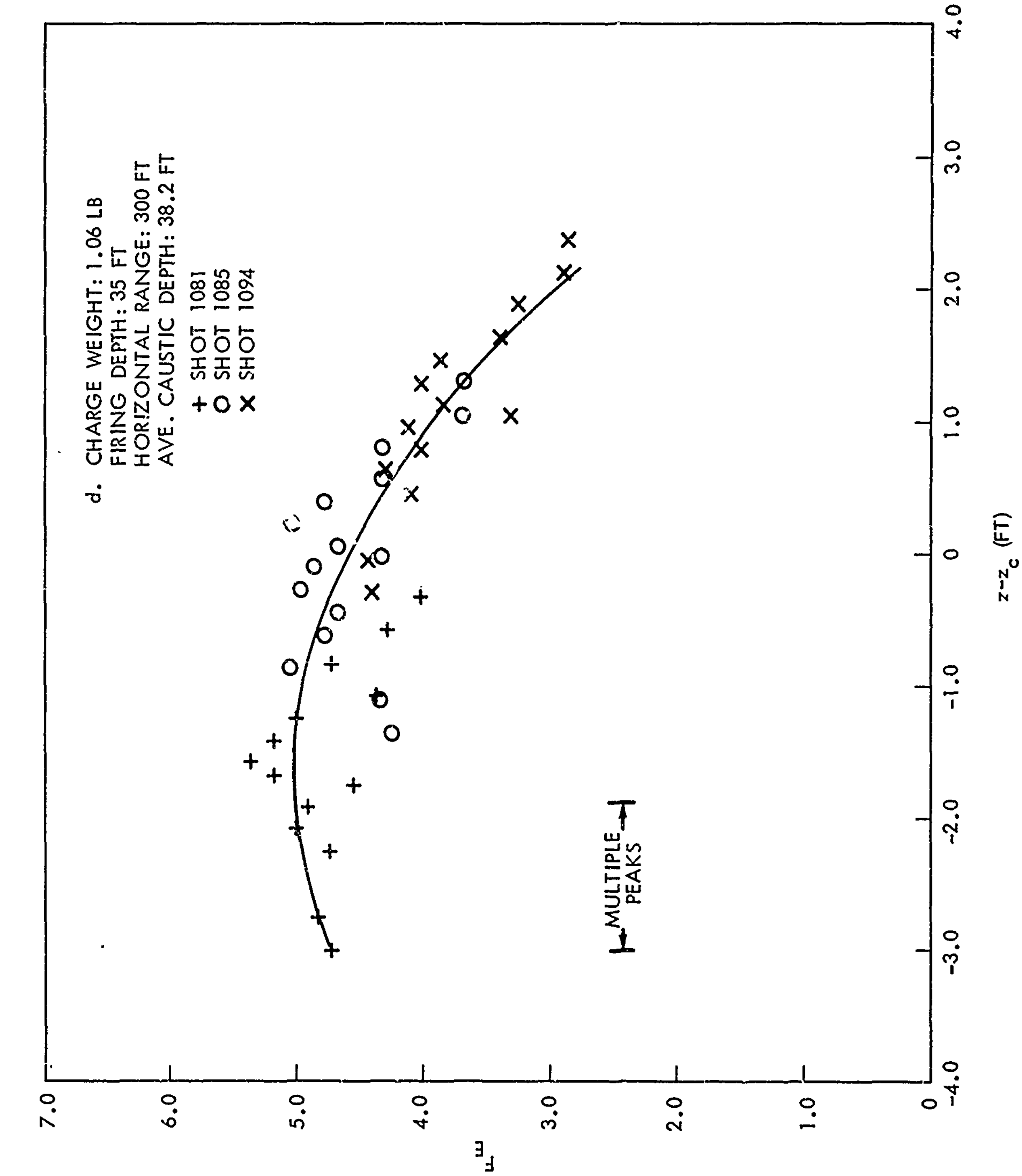


FIG. 13d ENERGY AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC

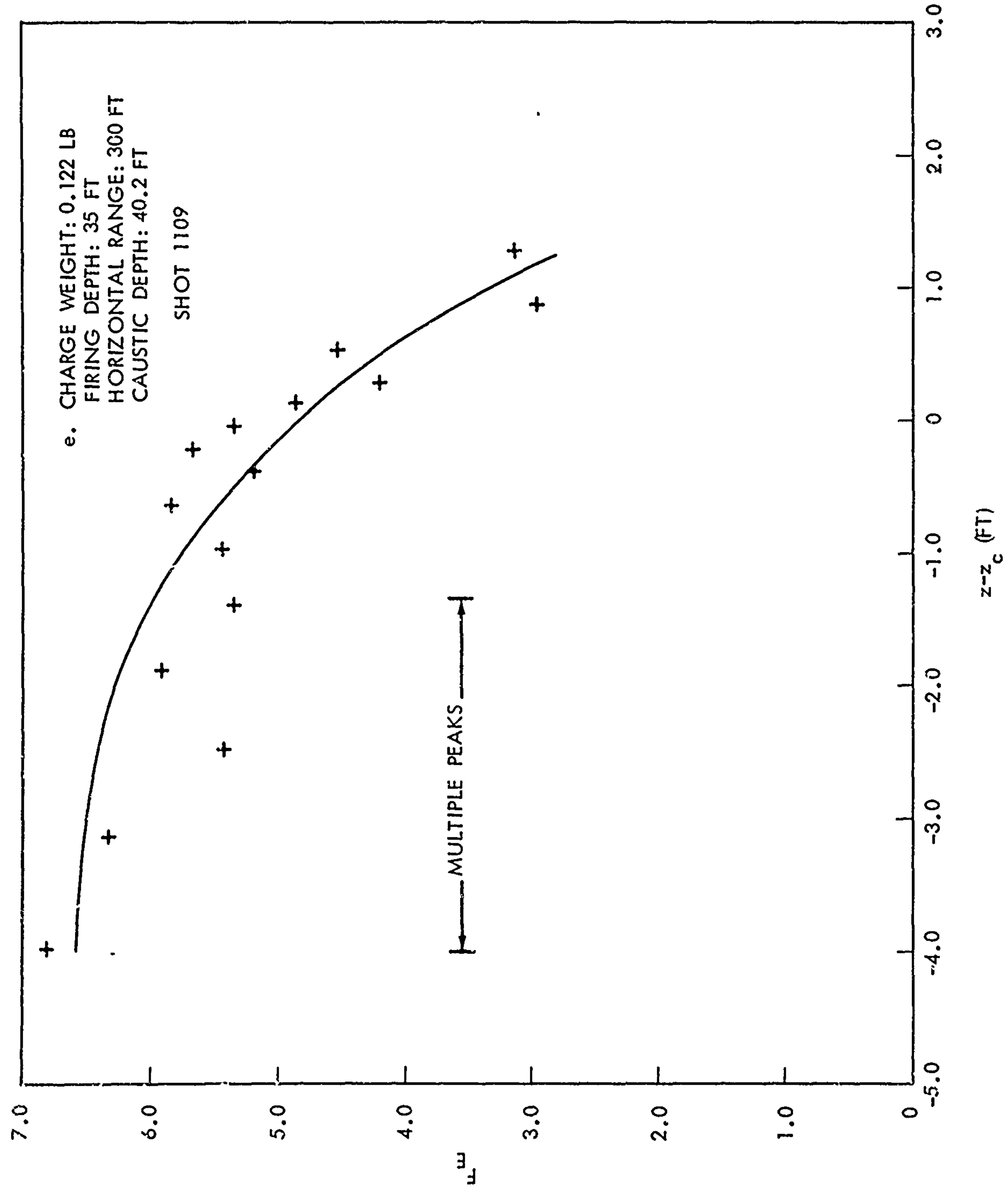


FIG. 13e ENERGY AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC

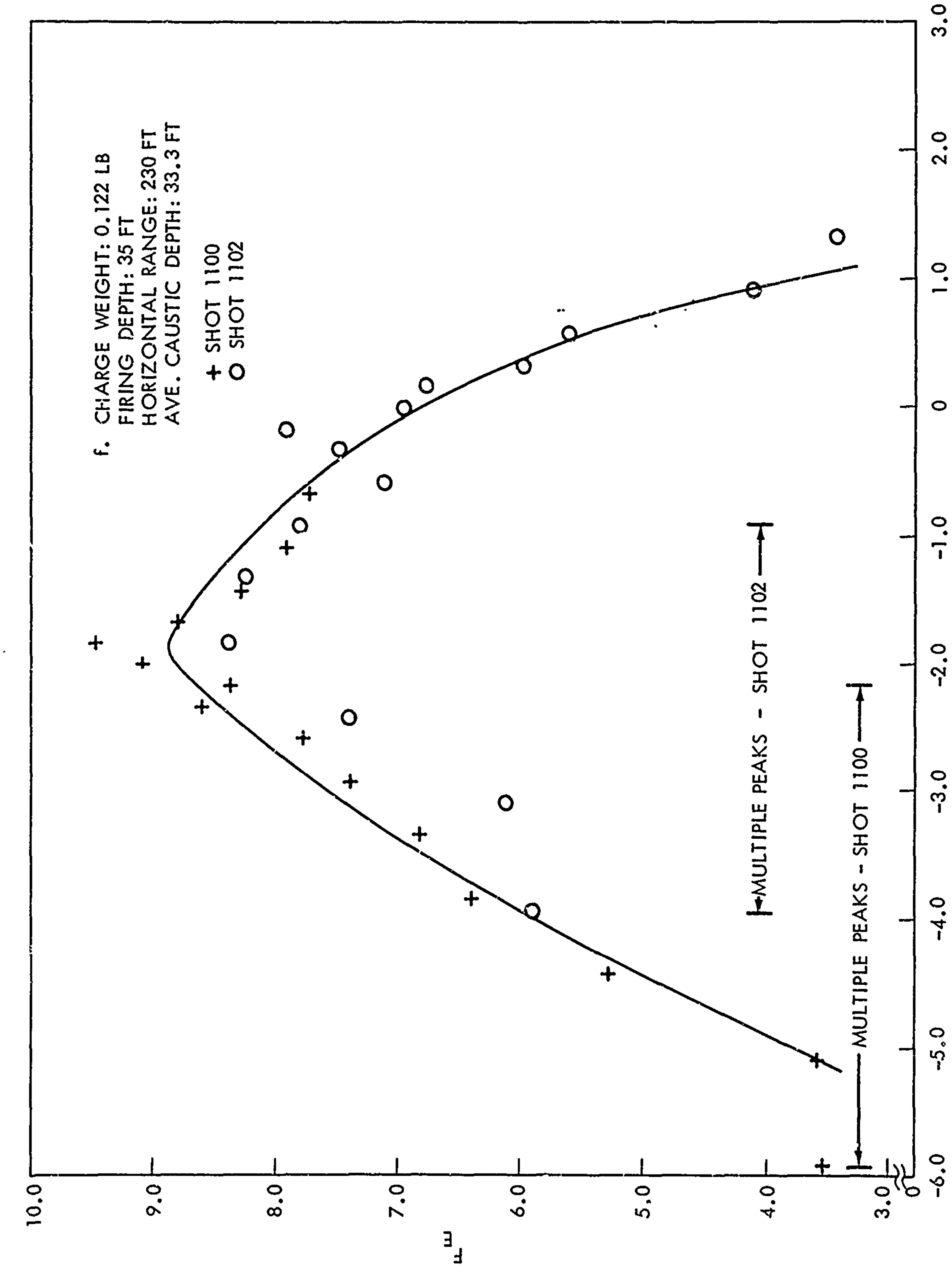


FIG. 13f ENERGY AMPLITUDE FACTOR VS VERTICAL DISTANCE FROM CAUSTIC

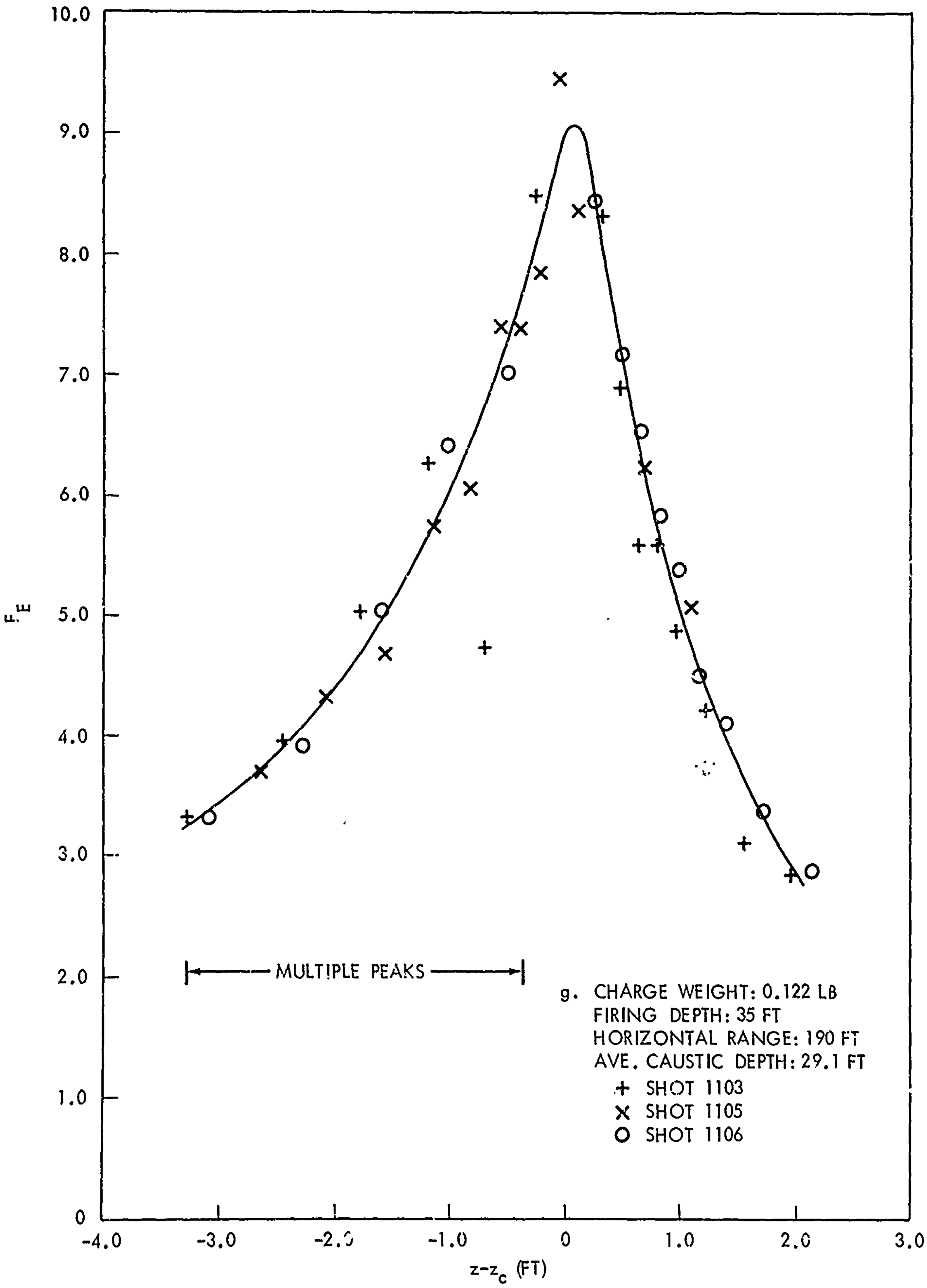


FIG. 13g ENERGY AMPLIFICATION FACTOR VS VERTICAL DISTANCE FROM CAUSTIC

TABLE I EXPERIMENTAL DATA

TERMS, SYMBOLS AND UNITS IN TABLE I ARE AS FOLLOWS:

DEPTH IN FT, PRESSURE IN LB/SQ IN, TIME IN SEC

P1 AND P2 ARE OBSERVED MAXIMUM PRESSURES FOR FIRST AND SECOND ARRIVALS, RESPECTIVELY
(* INDICATES NO SECOND ARRIVAL OBSERVED)
P1RISE = P1 - PRECURSOR PRESSURE AT TC
PM = MAXIMUM PEAK PRESSURE (EXTRAPOLATED OR OBSERVED, SEE SECTION V. A.)
I = TOTAL IMPULSE
IC = CAUSTIC-RELATED IMPULSE
$\int p^2\,dt$ (SEE SECTION V. A.)
F1RISE = P1RISE/PMISO
FP = PEAK PRESSURE AMPLIFICATION FACTOR AT PM
FI AND FIC = IMPULSE AMPLIFICATION FACTORS
FE = ENERGY AMPLIFICATION FACTOR

IMPULSE AND $\int p^2\,dt$ CALCULATED USING OBSERVED MAXIMUM PEAK PRESSURE

TABLE I CONTINUED

SHOT NO. 1078
CHARGE WEIGHT = 8.100 POUNDS
CHARGE DEPTH = 35. FEET
HORIZONTAL RANGE = 300. FEET
CAUSTIC DEPTH = 38.6 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	P1RISE	PM	I	IC		F1RISE	FP	FI	FIC	FE
C	35.50	158.	*	98.	158.	.0304	.0198	2.31	1.24	2.01	1.03	0.67	2.57
G	35.75	163.	*	99.	167.	.0293	.0192	2.20	1.28	2.11	0.99	0.65	2.44
A	35.92	175.	*	111.	180.	.0313	.0207	2.51	1.39	2.33	1.06	0.70	2.79
D	36.08	179.	*	118.	185.	.0300	.0206	2.43	1.51	2.37	1.01	0.70	2.70
B	36.25	188.	*	125.	195.	.0315	.0215	2.61	1.50	2.48	1.06	0.73	2.90
E	36.33	191.	*	128.	198.	.0318	.0215	2.68	1.64	2.52	1.07	0.73	2.98
H	36.42												
J	36.58	199.	*	141.	215.				1.80	2.71			
K	36.75	207.	*	155.	223.	.0308	.0218	2.70	1.97	2.85	1.04	0.74	3.00
L	36.92	218.	*	158.	233.	.0331	.0234	3.01	2.04	3.05	1.12	[illegible]	3.34
M	37.17	224.	*	173.	245.	.0309	.0223	2.87	2.20	3.15	1.04	0.75	3.19

SHOT NO. 1079
CHARGE WEIGHT = 8.095 POUNDS
CHARGE DEPTH = 35. FEET
HORIZONTAL RANGE = 300. FEET
CAUSTIC DEPTH = 38.6 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	P1RISE	PM	I	IC		F1RISE	FP	FI	FIC	FE
C	37.17	233.	*	181.	257.	.0309	.0220	2.94	2.30	3.30	1.04	0.77	3.05
G	37.42	243.	*	190.	267.	.0313	.0230	3.08	2.43	3.40	1.06	0.77	3.43
A	37.58	253.	*	201.	285.	.0310	.0226	3.24	2.57	3.63	1.05	0.82	3.60
D	37.75	259.	*	201.	290.	.0337	.0249	3.66	2.55	3.65	1.14	0.88	4.08
B	37.92	259.	*	205.	283.	.0328	.0245	3.59	2.63	3.65	1.11	0.86	4.00
E	38.00	264.	*	210.	281.	.0317	.0237	3.52	2.67	3.46	1.07	0.84	3.91
H	38.08	265.	*	217.	305.	.0306	.0230	3.21	2.77	3.95	1.03	0.78	3.57
J	38.25	268.	*	220.	300.	.0311	.0235	3.38	2.80	3.80	1.05	0.80	3.76
K	38.42	272.	*	222.	310.	.0317	.0243	3.55	2.84	3.95	1.07	0.82	3.95
L	38.58	273.	*	227.	300.	.0314	.0243	3.59	2.90	3.80	1.06	0.82	4.00
M	38.83												

TABLE I CONTINUED

SHOT NO. 1080
CHARGE WEIGHT = 8.091 POUNDS
CHARGE DEPTH = 35. FEET
HORIZONTAL RANGE = 300. FEET
CAUSTIC DEPTH = 38.6 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	PIRISE	PM	I	IC		FIRISE	FP	FI	FIC	FE
N2	37.67	252.	*	206.	285.	.0304	.0228	3.09	2.63	3.45	1.06	0.77	3.44
N1	37.92	269.	*	226.	300.	.0300	.0228	3.27	2.88	3.75	1.01	0.77	3.64
C	38.17												
G	38.42	284.	*	240.	320.	.0314	.0241	3.66	3.06	4.20	1.11	0.82	4.08
A	38.58	297.	*	250.	333.	.0336	.0259	4.08	3.20	4.40	1.14	0.88	4.54
D	38.75	292.	*	245.	325.	.0328	.0254	3.99	3.12	4.36	1.11	0.86	4.44
B	38.92	287.	*	246.	335.	.0313	.0247	3.89	3.15	4.10	1.06	0.84	4.33
E	39.00	289.	*	243.	315.	.0324	.0254	4.05	3.10	4.10	1.09	0.86	4.50
H	39.08	287.	*	243.	330.	.0322	.0258	3.96	3.11	4.10	1.09	0.87	4.41
J	39.25												
K	39.42	275.	*	232.	293.	.0325	.0262	4.06	2.95	3.70	1.10	0.89	4.52
L	39.58	263.	*	223.	275.	.0324	.0266	4.07	2.84	3.50	1.09	0.90	4.53
M	39.83	250.	*	210.	262.	.0331	.0276	4.08	2.68	3.35	1.12	0.93	4.54
N3	40.08	245.	*	209.	257.	.0320	.0270	3.99	2.66	3.25	1.08	0.91	4.44
N4	40.33	240.	*	203.	252.	.0310	.0263	3.83	2.60	3.30	1.05	0.89	4.26

SHOT NO. 1081
CHARGE WEIGHT = 1.060 POUNDS
CHARGE DEPTH = 35. FEET
HORIZONTAL RANGE = 300. FEET
CAUSTIC DEPTH = 37.0 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	PIRISE	PM	I	IC		FIRISE	FP	FI	FIC	FE
N2	37.33	120.	*	100.	120.	.0097	.0062	0.45	2.77	3.32	1.21	0.78	4.02
N1	37.58	125.	*	105.	125.	.0104	.0067	0.48	2.90	3.45	1.30	0.83	4.29
C	37.83	122.	*	104.	122.	.0101	.0068	0.53	2.85	3.35	1.26	0.85	4.73
G	38.00	110.	*	92.5	110.	.0098	.0068	0.49	2.56	3.03	1.22	0.85	4.37
A	38.25	117.	*	98.0	117.	.0107	.0074	0.56	2.70	3.23	1.33	0.92	5.00
D	38.42	117.	*	98.5	117.	.0109	.0077	0.58	2.73	3.23	1.36	0.96	5.18
B	38.58	115.	*	95.0	115.	.0109	.0078	0.60	2.61	3.16	1.36	0.97	5.36
E	38.67	115.	*	96.0	115.	.0108	.0077	0.58	2.66	3.17	1.35	0.97	5.18
H	38.75	109.	*	91.7	109.	.0100	.0072	0.51	2.53	3.00	1.25	0.90	4.56
J	38.92	82.7	110.	65.0	110.	.0107	.0077	0.55	1.80	3.03	1.33	0.96	4.91
K	39.08	80.5	106.	64.5	106.	.0106	.0078	0.56	1.77	2.92	1.32	0.98	5.00
L	39.25	77.0	103.	60.0	103.	.0102	.0077	0.53	1.67	2.83	1.27	0.96	4.73
M	39.50												
N3	39.75		99.		99.	.0106	.0083	0.54		2.73	1.32	1.04	4.82
N4	40.00		100.		100.	.0102	.0081	0.53		2.76	1.27	1.02	4.73

TABLE I CONTINUED

SHOT NO. 1082
CHARGE WEIGHT = 8.087 POUNDS
CHARGE DEPTH = 50. FEET
HORIZONTAL RANGE = 300. FEET
CAUSTIC DEPTH = 27.6 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	P1RISE	PM	I	IC		F1RISE	FP	FI	FIC	FE
N2	25.75	157.	*	83.0	157.	.0303	.0210	2.20	1.07	2.01	1.02	0.71	2.44
N1	26.00	163.	*	89.0	163.	.0329	.0230	2.50	1.16	2.10	1.11	0.78	2.78
C	26.25	186.	*	114.	195.	.0306	.0216	2.58	1.50	2.50	1.03	0.73	2.87
G	26.50	203.	*	133.	213.	.0293	.0206	2.59	1.33	2.75	0.99	0.70	2.88
A	26.67	228.	*	151.	245.	.0333	.0239	3.18	1.98	3.15	1.13	0.81	3.53
D	26.83	249.	*	172.	270.	.0320	.0231	3.28	2.22	3.50	1.08	0.78	3.65
B	27.00	256.	*	185.	280.	.0307	.0223	3.16	2.38	3.48	1.04	0.75	3.51
E	27.08	265.	*	190.	288.	.0319	.0242	3.35	2.43	3.75	1.08	0.82	3.73
H	27.17	278.	*	212.	330.	.0302	.0224	3.22	2.71	4.10	1.02	0.76	3.58
J	27.33	287.	*	220.	330.	.0298	.0223	3.28	2.84	4.05	1.01	0.75	3.65
K	27.50	297.	*	228.	335.	.0304	.0231	3.57	2.94	4.20	1.03	0.78	3.97
L	27.67	310.	*	245.	355.	.0313	.0239	3.71	3.16	4.50	1.06	0.81	4.13
M	27.92	305.	*	242.	355.	.0305	.0241	3.84	3.10	4.30	1.03	0.81	4.27
N3	28.17	287.	*	231.	308.	.0303	.0243	3.85	2.98	4.00	1.02	0.82	4.28
N4	28.42	282.	*	228.	308.	.0316	.0262	4.11	2.92	3.95	1.07	0.89	4.57

SHOT NO. 1083
CHARGE WEIGHT = 1.060 POUNDS
CHARGE DEPTH = 50. FEET
HORIZONTAL RANGE = 300. FEET
CAUSTIC DEPTH = 27.2 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	P1RISE	PM	I	IC		F1RISE	FP	FI	FIC	FE
N2	26.67	115.	*	86.5	136.	.0099	.0061	0.42	2.40	3.70	1.23	0.76	3.72
N1	26.92	124.	*	96.0	145.	.0102	.0066	0.47	2.73	4.00	1.27	0.82	4.16
C	27.17	135.	*	105.	165.	.0098	.0063	0.51	2.90	4.40	1.22	0.79	4.52
G	27.42	132.	*	103.	152.	.0097	.0065	0.53	2.85	4.10	1.21	0.81	4.69
A	27.58	133.	*	105.	147.	.0102	.0072	0.57	2.90	4.05	1.27	0.90	5.05
D	27.75	128.	*	99.0	142.	.0102	.0072	0.58	2.75	3.90	2.00	0.90	5.14
B	27.92	126.	*	101.	140.	.0104	.0076	0.62	2.80	3.95	1.30	0.95	5.48
E	28.00	131.	*	104.	146.	.0111	.0084	0.65	2.88	4.00	1.38	1.05	5.76
H	28.08												
J	28.25	98.5	119.	75.5	133.	.0099	.0076	0.58	2.00	3.65	1.23	0.95	5.14
K	28.42	92.0	115.	73.3	124.	.0102	.0080	0.62	2.03	3.50	1.27	1.00	5.49
L	28.58	86.0	110.	67.5	124.	.0099	.0079	0.58	1.87	3.40	1.23	0.98	5.14
M	28.83	82.7	110.	63.5	118.	.0102	.0084	0.60	1.76	3.40	1.27	1.05	5.31
N3	29.08	80.5	108.	60.5	122.	.0100	.0083	0.60	1.67	3.33	1.25	1.04	5.31
N4	29.33	75.5	103.	58.0	117.	.0099	.0085	0.57	1.60	3.25	1.23	1.06	5.05

TABLE I CONTINUED

SHOT NO. 1084
CHARGE WEIGHT = 8.109 POUNDS
CHARGE DEPTH = 50. FEET
HORIZONTAL RANGE = 300. FEET
CAUSTIC DEPTH = 27.4 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	P1RISE	PM	I	IC		F1RISE	FP	FI	FIC	FE
N2	26.33	205.	*	143.	218.	.0331	.0243	2.81	1.85	2.78	1.12	0.82	3.12
N1	26.58	222.	*	151.	240.	.0315	.0227	2.81	1.93	3.13	1.06	0.77	3.12
C	26.83	257.	*	183.	315.	.0307	.0219	3.08	2.33	3.85	1.04	0.74	3.42
G	27.08	278.	*	210.	330.	.0321	.0236	3.48	2.69	4.10	1.08	0.80	3.87
A	27.25	295.	*	224.	330.	.0313	.0237	3.62	2.88	4.45	1.06	0.80	4.03
D	27.42	300.	*	234.	360.	.0310	.0232	3.58	3.00	4.65	1.05	0.78	3.98
B	27.58	305.	*	240.	360.	.0309	.0235	3.74	3.08	4.50	1.04	0.79	4.15
E	27.67	303.	*	237.	335.	.0312	.0236	3.83	3.04	4.40	1.05	0.80	4.26
H	27.75	288.	*	229.	328.	.0304	.0237	3.60	2.95	4.25	1.03	0.80	4.00
J	27.92	293.	*	232.	323.	.0314	.0250	3.93	2.97	4.25	1.06	0.84	4.37
K	28.08	275.	*	215.	300.	.0317	.0259	3.95	2.75	3.85	1.07	0.87	4.39
L	28.25	277.	*	220.	305.	.0314	.0258	3.93	2.82	3.95	1.06	0.87	4.37
M	28.50	186.	275.	129.	305.	.0316	.0267	4.03	1.66	3.85	1.07	0.90	4.48
N3	28.75	174.	263.	125.	282.	.0306	.0263	3.94	1.60	3.60	1.03	0.89	4.38
N4	29.00	169.	257.	123.	282.	.0303	.0267	3.94	1.57	3.65	1.02	0.90	4.38

SHOT NO. 1085
CHARGE WEIGHT = 1.056 POUNDS
CHARGE DEPTH = 35. FEET
HORIZONTAL RANGE = 300. FEET
CAUSTIC DEPTH = 38.3 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	P1RISE	PM	I	IC		F1RISE	FP	FI	FIC	FE
N2	37.00	104.	*	76.2	118.	.0106	.0060	0.41	2.12	3.20	1.32	0.75	3.70
N1	37.25	108.	*	81.7	120.	.0102	.0062	0.41	2.27	3.40	1.27	0.77	3.70
C	37.50	118.	*	91.0	134.	.0110	.0064	0.48	2.51	3.65	1.37	0.80	4.33
G	37.75	122.	*	99.3	138.	.0107	.0064	0.48	2.74	3.80	1.33	0.80	4.33
A	37.92	126.	*	105.	142.	.0111	.0071	0.53	2.90	3.90	1.38	0.88	4.78
D	38.08	129.	*	107.	148.	.0114	.0071	0.56	2.96	4.20	1.42	0.88	5.04
B	38.25	126.	*	104.	144.	.0107	.0067	0.52	2.89	4.00	1.33	0.83	4.68
E	38.33	128.	*	109.	148.	.0097	.0061	0.48	3.02	3.90	1.21	0.76	4.33
H	38.42	129.	*	115.	150.	.0111	.0071	0.54	2.91	4.10	1.38	0.88	4.87
J	38.58	126.	*	101.	142.	.0108	.0070	0.55	2.80	3.90	1.35	0.87	4.96
K	38.75	122.	*	99.0	135.	.0104	.0068	0.52	2.72	3.65	1.30	0.85	4.68
L	38.92	118.	*	95.8	126.	.0103	.0070	0.53	2.65	3.55	1.28	0.87	4.78
M	39.17	115.	*	95.0	124.	.0108	.0074	0.56	2.63	3.40	1.35	0.92	5.04
N3	39.42	108.	*	93.0	116.	.0091	.0067	0.48	2.56	3.18	1.13	0.84	4.33
N4	39.67	108.	*	94.7	120.	.0090	.0065	0.47	2.61	3.25	1.12	0.82	4.24

TABLE I CONTINUED

SHOT NO. 1086
CHARGE WEIGHT = 8.102 POUNDS
CHARGE DEPTH = 25. FEET
HORIZONTAL RANGE = 300. FEET
CAUSTIC DEPTH = 59.4 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	P1RISE	PM	I	IC		F1RISE	FP	FI	FIC	FE
N2	58.00	253.	*	156.	275.	.0303	.0029	3.79	2.52	3.55	1.02	0.98	4.21
N1	58.25	262.	*	206.	283.	.0302	.0029	3.93	2.75	3.80	1.02	0.98	4.37
C	58.50	273.	*	216.	310.	.0305	.0030	4.16	2.78	4.00	1.03	1.01	4.63
G	58.75	282.	*	222.	310.	.0292	.0029	4.01	2.84	4.10	0.99	0.98	4.45
A	58.92	297.	*	297.	340.	.0312	.0312	4.48	3.82	4.20	1.05	1.05	4.97
D	59.08	310.	*	310.	345.	.0324	.0324	4.85	4.00	4.40	1.09	1.09	5.40
B	59.25	305.	*	305.	335.	.0301	.0301	4.53	3.92	4.25	1.02	1.02	5.04
E	59.33	328.	*	328.	378.	.0308	.0308	4.69	4.21	4.70	1.04	1.04	5.21
H	59.42	330.	*	330.	400.	.0274	.0274	4.19	4.26	4.70	0.93	0.93	4.66
J	59.58	318.	*	314.	365.	.0293	.0293	4.28	4.05	4.60	0.99	0.99	4.76
K	59.75	310.	*	310.	340.	.0294	.0294	4.33	3.98	4.50	0.99	0.99	4.81
L	59.92	318.	*	318.	360.	.0299	.0299	4.45	4.10	4.70	1.01	1.01	4.94
M	60.17	290.	*	290.	325.	.0290	.0290	4.19	3.74	4.20	0.98	0.98	4.66
N3	60.42	288.	*	288.	310.	.0304	.0304	4.35	3.70	4.00	1.03	1.03	4.83
N4	60.67	262.	*	262.	275.	.0316	.0316	4.18	3.37	3.55	1.07	1.07	4.65

SHOT NO. 1087
CHARGE WEIGHT = 1.055 POUNDS
CHARGE DEPTH = 25. FEET
HORIZONTAL RANGE = 300. FEET
CAUSTIC DEPTH = 59.3 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	P1RISE	PM	I	IC		F1RISE	FP	FI	FIC	FE
N2	58.33	134.	*	110.	158.	.0085	.0075	0.58	3.05	4.35	1.06	0.93	5.23
N1	58.58	140.	*	114.	158.	.0088	.0079	0.62	3.18	4.50	1.10	0.98	5.58
C	58.83	146.	*	119.	165.	.0091	.0083	0.68	3.30	4.60	1.13	1.03	6.12
G	59.08	146.	*	120.	175.	.0087	.0080	0.65	3.35	4.80	1.09	1.00	5.85
A	59.25	158.	*	130.	180.	.0095	.0089	0.77	3.61	5.10	1.18	1.11	6.93
D	59.42	149.	*	121.	170.	.0096	.0089	0.77	3.35	4.80	1.20	1.11	6.93
B	59.53	147.	*	119.	158.	.0096	.0091	0.76	3.32	4.48	1.20	1.13	6.85
E	59.67	148.	*	119.	168.	.0092	.0088	0.73	3.31	4.70	1.15	1.10	6.57
H	59.75	145.	*	118.	163.	.0089	.0086	0.72	3.27	4.60	1.11	1.07	6.48
J	59.92	143.	*	113.	158.	.0090	.0088	0.73	3.12	4.35	1.12	1.10	6.57
K	60.08	138.	*	138.	150.	.0091	.0091	0.75	3.83	4.25	1.13	1.13	6.76
L	60.25	136.	*	136.	136.	.0095	.0095	0.74	3.78	3.78	1.18	1.18	6.66
M	60.50	135.	*	135.	135.	.0092	.0092	0.73	3.78	3.78	1.15	1.15	6.57
N3	60.75	136.	*	136.	136.	.0089	.0089	0.69	3.78	3.78	1.11	1.11	6.21
N4	61.00	60.0	139.	60.0	139.	.0088	.0088	0.66	1.67	3.86	1.10	1.10	5.94

TABLE I CONTINUED

SHOT NO. 1088
CHARGE WEIGHT = 8.073 POUNDS
CHARGE DEPTH = 25. FEET
HORIZONTAL RANGE = 300. FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	P1RISE	PM	I	IC		F1RISE	FP	FI	FIC	FE
N2	6.00	38.2	*	38.2	38.2				0.49	0.49			
N1	6.25	34.5	*	34.5	34.5				0.44	0.44			
C	6.50	36.1	*	36.1	36.1				0.46	0.46			
G	6.75	36.1	*	36.1	36.1				0.46	0.46			
A	6.92	33.2	*	33.2	33.2				0.42	0.42			
D	7.08	37.3	*	37.3	37.3				0.48	0.48			
B	7.25	33.3	*	33.3	33.3				0.43	0.43			
E	7.33	35.6	*	35.6	35.6				0.46	0.46			
H	7.42	34.5	*	34.5	34.5				0.44	0.44			
J	7.58	34.2	*	34.2	34.2				0.44	0.44			
K	7.75	33.5	*	33.5	33.5				0.43	0.43			
L	7.92	32.9	*	32.9	32.9				0.42	0.42			
M	8.17	33.5	*	33.5	33.5				0.43	0.43			
N3	8.42	31.4	*	31.4	31.4				0.40	0.40			
N4	8.67	30.6	*	30.6	30.6				0.39	0.39			

SHOT NO. 1089
CHARGE WEIGHT = 8.095 POUNDS
CHARGE DEPTH = 35. FEET
HORIZONTAL RANGE = 230. FEET
CAUSTIC DEPTH = 33.9 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	P1RISE	PM	I	IC		F1RISE	FP	FI	FIC	FE
N2	33.25	422.	*	327.	450.	.0356	.0343	7.3	3.09	4.45	0.93	0.90	4.64
N1	33.50	440.	*	343.	480.	.0357	.0349	7.6	3.29	4.70	0.93	0.91	4.83
C	33.75	460.	*	370.	520.	.0368	.0365	8.1	3.52	5.00	0.96	0.96	5.15
G	34.00	445.	*	445.	520.	.0369	.0369	8.4	4.20	5.00	0.97	0.97	5.34
A	34.17	455.	*	287.	540.	.0397	.0384	8.9	2.71	4.85	1.04	1.01	5.66
D	34.33	179.	435.	179.	450.	.0377	.0377	7.7	1.68	4.70	0.99	0.99	4.89
B	34.50	175.	421.	175.	470.	.0382	.0382	7.8	1.65	4.70	1.00	1.00	4.96
E	34.58		431.		460.	.0384	.0384	8.0		4.37	1.01	1.01	5.08
H	34.67	164.	395.	164.	440.	.0368	.0368	7.2	1.54	4.20	0.96	0.96	4.58
J	34.83	161.	378.	161.	420.	.0376	.0376	7.3	1.52	3.90	0.98	0.98	4.64
K	35.00	161.	366.	161.	400.	.0377	.0377	7.0	1.53	3.80	0.99	0.99	4.45
L	35.17	156.	356.	156.	390.	.0386	.0386	7.0	1.48	3.68	1.01	1.01	4.45
M	35.42	160.	339.	160.	385.	.0393	.0393	6.7	1.51	3.50	1.03	1.03	4.26
N3	35.67	158.	330.	158.	350.	.0392	.0392	6.7	1.50	3.55	1.03	1.03	4.26
N4	35.92	150.	306.	150.	330.	.0390	.0390	6.3	1.42	3.10	1.02	1.02	4.01

TABLE I CONTINUED

SHOT NO. 1090
CHARGE WEIGHT = 1.055 POUNDS
CHARGE DEPTH = 35. FEET
HORIZONTAL RANGE = 230. FEET
CAUSTIC DEPTH = 32.8 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS P1	P2	PIRISE	PM	IMPULSE I	IC	$\int p^2\,dt$	AMPLIFICATION FACTORS FIRISE	FP	FI	FIC	FE
N2	31.25	138.	*	94.	150.	.0114	.0083	0.75	2.00	3.10	1.11	0.81	3.86
N1	31.50	145.	*	99.	160.	.0115	.0085	0.76	2.03	3.30	1.12	0.82	3.91
C	31.75	168.	*	123.	195.	.0115	.0088	0.90	2.48	3.85	1.12	0.85	4.63
G	32.00												
A	32.17	194.	*	144.	230.	.0122	.0098	1.14	2.94	4.60	1.18	0.95	5.86
D	32.33												
B	32.50	200.	*	149.	230.	.0123	.0103	1.20	3.02	4.60	1.19	1.00	6.17
E	32.58	203.	*	154.	225.	.0123	.0105	1.21	3.14	4.70	1.19	1.02	6.22
H	32.67	202.	*	153.	230.	.0118	.0103	1.18	3.20	4.60	1.15	1.00	6.06
J	32.83	203.	*	157.	230.	.0120	.0108	1.24	3.20	4.80	1.17	1.05	6.37
K	33.00	188.	*	138.	207.	.0120	.0111	1.25	2.85	4.15	1.17	1.08	6.42
L	33.17	190.	*	143.	210.	.0120	.0115	1.29	2.94	4.30	1.17	1.12	6.63
M	33.42		191.		215.	.0119	.0117	1.31		4.30	1.16	1.14	6.73
N3	33.67		188.		205.	.0122	.0120	1.35		4.15	1.18	1.17	6.94
N4	33.92		181.		195.	.0120	.0120	1.28		4.00	1.17	1.17	6.58

SHOT NO. 1091
CHARGE WEIGHT = 8.100 POUNDS
CHARGE DEPTH = 35. FEET
HORIZONTAL RANGE = 160. FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS P1	P2	PIRISE	PM	IMPULSE I	IC	$\int p^2\,dt$	AMPLIFICATION FACTORS FIRISE	FP	FI	FIC	FE
C	24.50	376.	*	376.	410.	.0462	.0462	9.0	2.36	2.57	0.86	0.86	2.66
G	24.75	378.	*	378.	440.	.0445	.0445	8.7	2.37	2.75	0.83	0.83	2.57
A	24.92	389.	*	389.	423.	.0489	.0489	10.0	2.45	2.66	0.91	0.91	2.95
D	25.08	389.	*	389.	435.	.0493	.0493	9.8	2.43	2.72	0.92	0.92	2.89
B	25.25	395.	*	395.	440.	.0499	.0499	10.0	2.47	2.75	0.93	0.93	2.95
E	25.33	386.	*	386.	417.	.0480	.0480	10.2	2.43	2.60	0.89	0.89	3.01
H	25.42	394.	*	394.	480.	.0463	.0463	9.4	2.11	2.80	0.86	0.86	2.78
J	25.58	372.	*	372.	405.	.0456	.0456	9.0	2.34	2.55	0.85	0.85	2.66
K	25.75	365.	*	365.	400.	.0478	.0478	9.3	2.29	2.51	0.89	0.89	2.75
L	25.92	348.	*	348.	362.	.0498	.0498	9.4	2.18	2.28	0.93	0.93	2.78
M	26.17	339.	*	339.	365.	.0477	.0477	9.0	2.13	2.29	0.89	0.89	2.66

TABLE I CONTINUED

SHOT NO. 1092
CHARGE WEIGHT = 1.059 POUNDS
CHARGE DEPTH = 35. FEET
HORIZONTAL RANGE = 160. FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	P1RISE	PM	I	IC		F1RISE	FP	FI	FIC	FE
N2	24.17	190.	*	190.	190.	.0145	.0145	1.46	2.57	2.57	1.00	1.00	3.52
N1	24.42	185.	*	185.	185.	.0129	.0129	1.29	2.50	2.50	0.89	0.89	3.11
C	24.67	195.	*	195.	195.	.0142	.0142	1.49	2.63	2.63	0.98	0.98	3.59
G	24.92	184.	*	184.	184.	.0134	.0134	1.37	2.50	2.50	0.92	0.92	3.30
A	25.08	181.	*	181.	181.	.0164	.0164	1.56	2.45	2.45	1.13	1.13	3.76
D	25.25	174.	*	174.	174.	.0152	.0152	1.53	2.35	2.35	1.05	1.05	3.68
B	25.42	158.		158.	158.	.0144	.0144	1.34	2.13	2.13	0.99	0.99	3.23
E	25.50	153.		153.	153.	.0149	.0149	1.39	2.07	2.07	1.03	1.03	3.35
H	25.58	140.	145.	140.	145.	.0152	.0152	1.30	1.90	1.97	1.05	1.05	3.13
J	25.75	135.	143.	135.	143.	.0157	.0157	1.34	1.82	1.94	1.08	1.08	3.23
K	25.92	135.	134.	135.	135.	.0161	.0161	1.31	1.83	1.83	1.11	1.11	3.15
L	26.08	128.	128.	128.	128.	.0160	.0160	1.32	1.73	1.73	1.10	1.10	3.18
M	26.33	128.	120.	128.	128.	.0159	.0159	1.26	1.73	1.73	1.10	1.10	3.03
N3	26.58	124.	113.	124.	124.	.0156	.0156	1.20	1.67	1.67	1.08	1.08	2.89
N4	26.83	114.	106.	114.	114.	.0149	.0149	1.15	1.54	1.54	1.03	1.03	2.77

SHOT NO. 1093
CHARGE WEIGHT = 53.500 POUNDS
CHARGE DEPTH = 35. FEET
HORIZONTAL RANGE = 300. FEET
CAUSTIC DEPTH = 42.4 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	P1RISE	PM	I	IC		F1RISE	FP	FI	FIC	FE
N2	37.00	277.	*	131.	277.	.077	.055	12.5	0.83	1.73	0.76	0.54	1.97
N1	37.25	279.	*	136.	279.	.078	.056	13.0	0.85	1.74	0.77	0.55	2.04
C	37.50	297.	*	158.	297.	.082	.061	14.2	0.99	1.86	0.81	0.60	2.23
G	37.75	298.	*	166.	298.	.080	.060	13.8	1.30	1.86	0.79	0.59	2.17
A	37.92	320.	*	171.	320.	.086	.066	15.8	1.07	2.00	0.85	0.65	2.49
D	38.08	330.	*	182.	330.	.086	.066	15.9	1.15	2.07	0.85	0.65	2.50
B	38.25	330.	*	180.	330.	.086	.066	15.9	1.13	2.07	0.85	0.65	2.50
E	38.33	334.	*	192.	334.	.087	.067	16.2	1.21	2.10	0.86	0.66	2.55
H	38.42	332.	*	192.	332.	.083	.065	15.0	1.22	2.08	0.82	0.64	2.35
J	38.58	351.	*	204.	351.	.086	.067	16.1	1.27	2.20	0.85	0.67	2.53
K	38.75	355.	*	216.	355.	.085	.067	16.0	1.38	2.23	0.84	0.67	2.52
L	38.92	362.	*	228.	370.	.085	.068	16.2	1.42	2.31	0.84	0.67	2.55
M	39.17	370.	*	240.	376.	.085	.068	16.4	1.50	2.37	0.84	0.68	2.58
N3	39.42	390.	*	263.	408.	.086	.070	16.9	1.64	2.57	0.85	0.69	2.67
N4	39.67	405.	*	272.	445.	.085	.070	16.8	1.68	2.75	0.84	0.69	2.64

TABLE I CONTINUED

SHOT NO. 1094
CHARGE WEIGHT = 1.074 POUNDS
CHARGE DEPTH = 35. FEET
HORIZONTAL RANGE = 300. FEET
CAUSTIC DEPTH = 39.2 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	P1RISE	PM	I	IC		F1RISE	FP	FI	FIC	FE
N2	36.83	77.0	*	50.7	77.0	.0100	.0056	0.320	1.38	2.11	1.25	0.70	2.64
N1	37.08	78.5	*	52.3	78.5	.0100	.0058	0.325	1.43	2.15	1.25	0.73	2.88
C	37.33	90.3	*	62.0	100.	.0103	.0060	0.366	1.76	2.75	1.28	0.75	3.24
G	37.58	97.7	*	70.0	108.	.0103	.0060	0.383	1.95	3.05	1.28	0.75	3.39
A	37.75	106.	*	77.3	118.	.0109	.0064	0.440	2.15	3.30	1.36	0.80	3.89
D	37.92	110.	*	84.0	124.	.0107	.0064	0.452	2.31	3.50	1.33	0.79	4.00
B	38.08	112.	*	85.7	126.	.0104	.0062	0.434	2.36	3.50	1.30	0.77	3.64
E	38.17	112.	*	92.0	128.	.0087	.0056	0.374	2.52	3.50	1.08	0.70	3.32
H	38.25	121.	*	94.0	142.	.0108	.0066	0.465	2.64	3.90	1.35	0.82	4.12
J	38.42	120.	*	95.2	136.	.0102	.0061	0.454	2.65	3.70	1.27	0.77	4.02
K	38.58	124.	*	102.	144.	.0104	.0066	0.485	2.78	3.90	1.30	0.82	4.30
L	38.75	128.	*	106.	150.	.0097	.0062	0.463	2.90	4.00	1.21	0.78	4.10
M	39.00												
N3	39.25	132.	*	116.	152.	.0097	.0065	0.503	3.13	4.30	1.21	0.81	4.45
N4	39.50	135.	*	117.	158.	.0098	.0065	0.497	3.14	4.30	1.22	0.81	4.40

SHOT NO. 1095
CHARGE WEIGHT = 8.049 POUNDS
CHARGE DEPTH = 35. FEET
HORIZONTAL RANGE = 300. FEET
CAUSTIC DEPTH = 41.1 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	P1RISE	PM	I	IC		F1RISE	FP	FI	FIC	FE
N2	38.17	163.	*	85.0	163.	.0326	.0212	2.52	1.11	2.08	1.10	0.72	2.81
N1	38.42	161.	*	104.	161.	.0306	.0208	2.33	1.31	2.06	1.03	0.70	2.61
C	38.67	180.	*	122.	180.	.0338	.0232	2.80	1.56	2.31	1.14	0.78	3.14
G	38.92	186.	*	125.	193.	.0312	.0210	2.68	1.65	2.48	1.05	0.71	3.00
A	39.08	200.	*	138.	210.	.0343	.0239	3.04	1.78	2.67	1.16	0.81	3.40
D	39.25	211.	*	147.	227.	.0363	.0257	3.28	1.86	2.90	1.23	0.87	3.67
B	39.42	214.	*	154.	228.	.0335	.0240	3.02	1.97	2.92	1.13	0.81	3.37
E	39.50	210.	*	146.	221.	.0313	.0222	2.87	1.88	2.85	1.06	0.75	3.21
H	39.58	220.	*	163.	248.	.0318	.0228	2.85	2.08	3.15	1.07	0.77	3.19
J	39.75	223.	*	152.	240.	.0305	.0216	2.79	1.95	3.15	1.03	0.73	3.13
K	39.92	232.	*	173.	258.	.0326	.0235	3.16	2.22	3.30	1.10	0.79	3.54
L	40.08	235.	*	178.	257.	.0306	.0222	3.03	2.27	3.12	1.03	0.75	3.39
M	40.33	244.	*	189.	270.	.0320	.0236	3.22	2.41	3.40	1.08	0.80	3.60
N3	40.58	256.	*	204.	290.	.0314	.0233	3.30	2.61	3.80	1.06	0.79	3.69
N4	40.83	264.	*	211.	315.	.0305	.0234	3.29	2.69	3.95	1.03	0.79	3.68

TABLE I CONTINUED

SHOT NO. 1096
CHARGE WEIGHT = 8.054 POUNDS
CHARGE DEPTH = 35. FEET
HORIZONTAL RANGE = 300. FEET
CAUSTIC DEPTH = 41.6 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	P1RISE	PM	I	IC		F1RISE	FP	FI	FIC	FE
N2	41.00	268.	*	215.	300.	.0327	.0253	3.75	2.75	3.90	1.10	0.86	4.19
N1	41.25	274.	*	223.	315.	.0311	.0244	3.60	2.85	3.90	1.05	0.82	4.03
C	41.50	284.	*	233.	310.	.0337	.0270	4.10	2.96	4.10	1.14	0.91	4.56
G	41.75	284.	*	231.	315.	.0343	.0282	4.25	2.96	4.30	1.16	0.95	4.75
A	41.92	285.	*	233.	310.	.0330	.0269	4.30	2.97	3.90	1.12	0.91	4.81
D	42.08	273.	*	221.	300.	.0321	.0263	4.01	2.82	3.70	1.08	0.89	4.49
B	42.25	273.	*	222.	288.	.0348	.0292	4.53	2.83	3.60	1.18	0.99	5.07
E	42.33	268.	*	217.	285.	.0332	.0279	4.35	2.77	3.55	1.12	0.94	4.86
H	42.42	259.	*	208.	282.	.0325	.0276	4.15	2.66	3.48	1.10	0.93	4.65
J	42.58	259.	*	211.	282.	.0319	.0273	4.04	2.69	3.65	1.08	0.92	4.52
K	42.75	251.	*	203.	262.	.0326	.0282	4.29	2.60	3.30	1.10	0.95	4.80
L	42.92	247.	*	200.	260.	.0322	.0281	4.10	2.55	3.25	1.09	0.95	4.58
M	43.17	243.	*	197.	243.	.0329	.0292	4.22	2.53	3.11	1.11	0.99	4.73
N3	43.42	241.		198.	241.	.0364	.0272	3.94	2.54	3.08	1.03	0.92	4.41
N4	43.67	163.	[illegible]36.	119.	236.	.0307	.0279	4.02	1.52	3.03	1.04	0.94	4.50

SHOT NO. 1097
CHARGE WEIGHT = 53.374 POUNDS
CHARGE DEPTH = 35. FEET
HORIZONTAL RANGE = 300. FEET
CAUSTIC DEPTH = 42.4 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	P1RISE	PM	I	IC		F1RISE	FP	FI	FIC	FE
N2	40.33	433.	*	333.	465.	.083	.071	17.5	2.08	2.90	0.82	0.70	2.76
N1	40.75	450.	*	350.	480.	.081	.070	17.1	2.17	3.00	0.80	0.70	2.70
C	41.08	48[illegible].	*	380.	528.	.089	.079	19.9	2.37	3.29	0.88	0.78	3.13
G	41.33	500.	*	397.	550.	.085	.075	19.8	2.48	3.45	0.84	0.75	3.12
A	41.50	515.	*	407.	548.	.091	.081	21.4	2.55	3.50	0.90	0.81	3.38
D	41.67	501.	*	393.	540.	.093	.084	21.9	2.46	3.45	0.92	0.83	3.45
B	41.83	524.	*	424.	580.	.090	.082	22.2	2.65	3.45	0.89	0.81	3.50
E	42.00	516.	*	416.	560.	.095	.087	22.4	2.60	3.45	0.94	0.86	3.53
H	42.25	530.	*	433.	580.	.085	.078	21.0	2.72	3.70	0.84	0.77	3.31
J	42.58	532.	*	436.	550.	.086	.080	21.0	2.73	3.70	0.85	0.79	3.31
K	43.00	533.	*	435.	570.	.086	.081	22.1	2.73	3.60	0.85	0.81	3.48
L	43.50	538.	*	442.	580.	.085	.082	22.4	2.73	3.60	0.84	0.81	3.53
M	44.08	514.	*	437.	550.	.087	.086	23.4	2.74	3.40	0.86	0.85	3.69
N3	44.75	496.	*	496.	515.	.086	.086	22.9	3.10	3.25	0.85	0.85	3.61
N4	45.58	206.	501.	206.	550.	.092	.092	22.0	1.30	3.40	0.91	0.91	3.47

TABLE I CONTINUED

SHOT NO. 1098
CHARGE WEIGHT = 8.087 POUNDS
CHARGE DEPTH = 25. FEET
HORIZONTAL RANGE = 300. FEET
CAUSTIC DEPTH = 2.3 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	P1RISE	PM	I	IC		F1RISE	FP	FI	FIC	FE
N2	1.58	60.9	*	60.9	75.0				0.78	1.00			
N1	2.00	78.0	*	78.0	100.				1.00	1.30			
C	2.33	85.7	*	85.7	108.				1.10	1.46			
G	2.58	79.5	*	79.5	107.				1.02	1.26			
A	2.75	82.7	*	82.7	102.				1.06	1.34			
D	2.92		77.8		94.0					1.28			
B	3.08		79.5		108.					1.22			
E	3.25	51.3	78.5	51.3	96.0				0.66	1.18			
H	3.50	50.0	72.2	50.0	86.0				0.65	1.16			
J	3.83												
K	4.25	48.0	70.0	48.0	87.0				0.61	1.10			
L	4.75	46.0	67.7	46.0	86.0				0.59	1.10			
M	5.33	45.0	63.3	45.0	78.0				0.57	1.08			
N3	6.00	40.4	57.2	40.4	74.0				0.52	0.96			
N4	6.83	38.7	51.5	38.7	64.0				0.50	0.84			

SHOT NO. 1099
CHARGE WEIGHT = 8.424 POUNDS
CHARGE DEPTH = 35. FEET
HORIZONTAL RANGE = 230. FEET
CAUSTIC DEPTH = 34.7 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	P1RISE	PM	I	IC		F1RISE	FP	FI	FIC	FE
N2	33.67	366.	*	270.	400.	.0346	.0322	6.3	2.52	3.70	0.89	0.82	3.85
N1	34.08	410.	*	316.	460.	.0355	.0339	6.7	2.93	4.25	0.91	0.87	4.09
C	34.42	462.	*	462.	515.	.0389	.0389	8.2	4.30	4.75	0.99	0.99	5.01
G	34.67	483.	*	483.	560.	.0362	.0362	8.5	4.50	5.20	0.93	0.93	5.19
A	34.83	480.	*	480.	530.	.0366	.0366	8.8	4.47	5.10	0.94	0.94	5.37
D	35.00	460.	*	460.	520.	.0373	.0373	8.5	4.27	4.80	0.95	0.95	5.19
B	35.17	445.	*	445.	500.	.0359	.0359	8.5	4.14	4.85	0.92	0.92	5.19
E	35.33		446.		490.	.0399	.0399	8.3		4.50	1.02	1.02	5.07
H	35.58	170.	415.	170.	470.	.0361	.0361	7.2	1.58	4.40	0.92	0.92	4.39
J	35.92	162.	379.	162.	420.	.0377	.0377	7.3	1.51	3.95	0.96	0.96	4.46
K	36.33	170.	353.	170.	350.	.0378	.0378	6.6	1.58	3.70	0.97	0.97	4.03
L	36.83	156.	306.	156.	320.	.0401	.0401	6.7	1.45	2.98	1.03	1.03	4.09
M	37.42	153.	263.	153.	275.	.0397	.0397	5.9	1.42	2.55	1.02	1.02	3.60
N3	38.08	143.	228.	143.	228.	.0393	.0393	5.4	1.34	2.13	1.01	1.01	3.30
N4	38.92	142.	191.	142.	151.	.0391	.0391	4.6	1.32	1.78	1.00	1.00	2.81

TABLE I CONTINUED

SHOT NO. 1100
CHARGE WEIGHT = 0.122 POUNDS
CHARGE DEPTH = 35. FEET
HORIZONTAL RANGE = 230. FEET
CAUSTIC DEPTH = 33.0 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	P1RISE	PM	I	IC		F1RISE	FP	FI	FIC	FE
N2	33.67	86.3	*	66.3	98.0	.00366	.00366	0.164	3.05	4.45	1.45	1.45	7.72
N1	34.08	80.7	*	21.8	94.0	.00368	.00368	0.168	1.00	4.25	1.45	1.45	7.91
C	34.42	80.0	*	23.3	92.0	.00360	.00360	0.176	1.08	4.30	1.42	1.42	6.28
G	34.67	79.2	*	25.0	94.0	.00371	.00371	0.187	1.11	4.20	1.47	1.47	8.80
A	34.83	81.2	*	24.5	93.0	.00393	.00393	0.201	1.13	4.20	1.55	1.55	9.47
D	35.00	81.2	*	25.7	93.0	.00395	.00395	0.193	1.20	4.30	1.56	1.56	9.08
B	35.17	35.0	78.5	35.0	88.0	.00383	.00383	0.178	1.62	4.10	1.51	1.51	8.37
E	35.33	35.0	81.8	35.0	92.0	.00397	.00397	0.183	1.61	4.25	1.57	1.57	6.61
H	35.58	34.2	77.0	34.2	88.0	.00385	.00385	0.165	1.58	4.20	1.52	1.52	7.77
J	35.92	33.5	79.0	33.5	92.0	.00390	.00390	0.157	1.54	4.20	1.54	1.54	7.39
K	36.33	34.2	80.0	34.2	102.	.00392	.00392	0.145	1.57	4.80	1.55	1.55	6.82
L	36.83	32.0	74.0	32.0	85.0	.00404	.00404	0.136	1.47	3.85	1.60	1.60	6.40
M	37.42	30.1	58.7	30.1	70.0	.00408	.00408	0.112	1.40	3.20	1.61	1.61	5.27
N3	38.08	27.0	46.4	27.0	54.0	.00343	.00343	0.076	1.25	2.45	1.36	1.36	3.58
N4	38.92	30.3	30.0	30.3	35.0	.00395	.00395	0.075	1.40	1.57	1.56	1.56	3.53

SHOT NO. 1101
CHARGE WEIGHT = 8.382 POUNDS
CHARGE DEPTH = 25. FEET
HORIZONTAL RANGE = 230. FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	P1RISE	PM	I	IC		F1RISE	FP	FI	FIC	FE
N2	0.67	95.5	*	95.5	95.5				0.90	0.90			
N1	1.08	96.2	*	96.2	96.2				0.91	0.91			
C	1.42	98.0	*	98.0	98.0				0.92	0.92			
G	1.67	93.5	*	93.5	93.5				0.88	0.88			
A	1.83	87.2	93.0	87.2	93.0				0.82	0.88			
D	2.00	82.0	93.0	82.0	93.0				0.77	0.87			
B	2.17	78.5	88.7	78.5	88.7				0.74	0.83			
E	2.33	77.3	85.7	77.3	85.7				0.72	0.80			
H	2.58	76.0	91.0	76.0	81.0				0.71	0.71			
J	2.92	73.5	75.0	73.5	75.0				0.69	0.71			
K	3.33	76.0	69.7	76.0	76.0				0.71	0.71			
L	3.83	71.5	69.8	71.5	71.5				0.67	0.67			
M	4.42	69.0	58.7	69.0	69.0				0.65	0.65			
N3	5.08	68.0	55.0	68.0	68.0				0.64	0.64			
N4	5.92	62.7	47.0	62.7	62.7				0.59	0.59			

TABLE I CONTINUED

SHOT NO. 1102
CHARGE WEIGHT = 0.122 POUNDS
CHARGE DEPTH = 35. FEET
HORIZONTAL RANGE = 230. FEET
CAUSTIC DEPTH = 33.5 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	P1RISE	PM	I	IC		F1RISE	FP	FI	FIC	FE
N2	32.17	52.0	*	32.7	61.0	.00303	.00188	0.073	1.50	2.70	1.20	0.74	3.43
N1	32.58	58.1	*	42.6	65.0	.00317	.00207	0.087	1.97	2.95	1.25	0.82	4.10
C	32.92	76.2	*	54.0	90.0	.00355	.00227	0.119	2.53	4.10	1.40	0.90	5.60
G	33.17	81.3	*	64.2	94.0	.00341	.00241	0.127	2.96	4.30	1.35	0.95	5.98
A	33.33	85.8	*	65.0	100.	.00357	.00267	0.144	3.02	4.60	1.41	1.06	6.78
D	33.50	88.8	*	69.5	104.	.00354	.00259	0.148	3.20	4.90	1.40	1.02	6.97
B	33.67	90.3	*	70.3	104.	.00360	.00280	0.169	3.10	4.70	1.42	1.11	7.91
E	33.83	88.5	*	67.0	103.	.00362	.00287	0.159	3.11	4.75	1.43	1.13	7.48
H	34.08	80.0	*	63.5	91.0	.00337	.00285	0.151	2.92	4.20	1.33	1.13	7.11
J	34.42		82.0		93.0	.00351	.00321	0.166		4.40	1.39	1.27	7.81
K	34.83	53.7	79.5		91.0	.00357	.00349	0.175		4.40	1.41	1.38	8.24
L	35.33	52.0	79.3		90.0	.00382	.00354	0.178		4.00	1.51	1.40	8.37
M	35.92	34.2	78.0	34.2	92.0	.00379	.00379	0.157	1.59	4.30	1.50	1.50	7.29
N3	36.58	32.0	75.2	32.0	83.0	.00369	.00369	0.130	1.48	3.90	1.46	1.46	6.12
N4	37.42	30.5	62.5	30.7	69.0	.00538	.00538	0.125	1.41	3.55	2.13	2.13	5.89

SHOT NO. 1103
CHARGE WEIGHT = 0.122 POUNDS
CHARGE DEPTH = 35. FEET
HORIZONTAL RANGE = 190. FEET
CAUSTIC DEPTH = 28.8 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	P1RISE	PM	I	IC		F1RISE	FP	FI	FIC	FE
N2	26.83	35.8	*	35.8	41.0	.00344	.00344	0.090	1.33	1.55	1.14	1.14	2.86
N1	27.25	40.5	*	36.9	40.5	.00338	.00338	0.098	1.36	1.50	1.12	1.12	3.12
C	27.58	50.8	*	42.3	50.8	.00374	.00374	0.133	1.58	1.90	1.23	1.23	4.22
G	27.83	58.7	*	58.7	58.7	.00395	.00395	0.154	2.18	2.18	1.30	1.30	4.89
A	28.00	71.0	*	71.0	78.0	.00377	.00377	0.176	2.65	2.90	1.24	1.24	5.59
D	28.17	75.0	*	75.0	82.0	.00355	.00355	0.176	2.79	3.03	1.17	1.17	5.59
B	28.33	98.8	*	98.8	110.	.00351	.00351	0.217	3.68	4.10	1.16	1.16	6.90
E	28.50	112.	*	112.	127.	.00382	.00382	0.262	4.15	4.65	1.26	1.26	8.32
H	28.75		*										
J	29.08	124.	*	124.	147.	.00351	.00351	0.267	4.62	5.60	1.16	1.16	8.48
K	29.50	85.0	*	85.0	85.0	.00395	.00395	0.225	3.15	3.15	1.30	1.30	4.74
L	30.00	59.5	65.0	59.5	65.0	.00411	.00411	0.198	2.22	2.41	1.36	1.36	6.28
M	30.58	50.8	47.1	50.8	50.8	.00413	.00413	0.159	1.89	1.89	1.36	1.36	5.05
N3	31.25	44.5		44.5	48.5	.00401	.00401	0.125	1.66	1.77	1.32	1.32	2.97
N4	32.08	38.5		38.5	38.5	.00417	.00417	0.105	1.43	1.43	1.38	1.38	3.33

TABLE I CONTINUED

SHCT NC. 1104
CHARGE WEIGHT = 8.386 POUNDS
CHARGE DEPTH = 35. FEET
HORIZONTAL RANGE = 190. FEET
CAUSTIC DEPTH = 29.3 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	P1RISE	PM	I	IC		F1RISE	FP	FI	FIC	FE
N2	27.67	258.	*	258.	258.	.0395	.0395	6.2	1.93	1.93	0.86	0.86	2.53
N1	28.08	293.	*	293.	293.	.0378	.0378	6.4	2.21	2.21	0.82	0.82	2.61
C	28.42	376.	*	376.	397.	.0424	.0424	8.2	2.82	2.95	0.92	0.92	3.35
G	28.67	397.	*	397.	425.	.0406	.0406	8.0	2.98	3.15	0.88	0.88	3.26
A	28.83	466.	*	466.	580.	.0402	.0402	8.9	3.50	3.85	0.87	0.87	3.64
D	29.00	468.	*	468.	560.	.0402	.0402	8.6	3.50	4.15	0.87	0.87	3.52
B	29.17	580.	*	580.	650.	.0414	.0414	10.5	4.36	4.80	0.90	0.90	4.29
E	29.33	500.	*	500.	650.	.0412	.0412	9.8	3.75	4.05	0.89	0.89	4.01
H	29.58	491.	*	491.	590.	.0401	.0401	9.2	3.79	4.40	0.87	0.87	3.76
J	29.92	405.	*	405.	420.	.0404	.0404	9.0	3.04	3.12	0.87	0.87	3.68
K	30.33	332.	*	332.	332.	.0423	.0423	8.2	2.50	2.50	0.92	0.92	3.35
L	30.83	238.	298.	238.	297.	.0440	.0440	8.4	1.78	2.23	0.95	0.95	3.43
M	31.42	221.	256.	221.	256.	.0437	.0437	7.4	1.65	1.93	0.95	0.95	3.02
N3	32.08	191.	215.	191.	215.	.0658	.0658	6.7	1.43	1.51	1.42	1.42	2.73
N4	32.92	187.	187.	187.	187.	.0497	.0497	6.4	1.40	1.40	1.08	1.08	2.61

SHCT NC. 1105
CHARGE WEIGHT = 0.122 POUNDS
CHARGE DEPTH = 35. FEET
HORIZONTAL RANGE = 190. FEET
CAUSTIC DEPTH = 29.1 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	P1RISE	PM	I	IC		F1RISE	FP	FI	FIC	FE
N2	28.00	78.0	*	30.8	89.0	.00352	.00352	0.160	1.14	3.23	1.16	1.16	5.08
N1	28.42	98.6	*	31.7	113.	.00351	.00351	0.197	1.16	4.30	1.16	1.16	6.25
C	28.75		*										
G	29.00	120.	*	120.	142.	.00349	.00349	0.263	4.47	5.30	1.15	1.15	8.36
A	29.17	123.	*	123.	142.	.00383	.00383	0.298	4.58	5.30	1.26	1.26	9.46
D	29.33	108.	*	108.	126.	.00374	.00374	0.247	4.01	4.60	1.23	1.23	7.85
B	29.50		102.		116.	.00391	.00391	0.233		4.25	1.29	1.29	7.40
E	29.67		101.		115.	.00402	.00402	0.233		4.35	1.33	1.33	7.40
H	29.92	48.2	85.7	48.2	99.	.00385	.00385	0.191	1.79	3.50	1.27	1.27	6.07
J	30.25	45.0	72.0	45.0	81.0	.00407	.00407	0.181	1.67	3.00	1.34	1.34	5.75
K	30.67	40.0	60.0	40.0	68.0	.00396	.00396	0.148	1.49	2.47	1.31	1.31	4.70
L	31.17	39.4	51.4	39.4	56.5	.00416	.00416	0.137	1.47	2.12	1.37	1.37	4.35
M	31.75	38.8	39.5	38.8	43.0	.00433	.00433	0.117	1.44	1.62	1.43	1.43	3.72
N3	32.42	36.0	29.0	36.0	38.3				1.34	1.40			
N4	33.25	36.2	23.1	36.2	37.0				1.35	1.37			

TABLE I CONTINUED

SHOT NO. 1106
CHARGE WEIGHT = 0.122 POUNDS
CHARGE DEPTH = 35. FEET
HORIZONTAL RANGE = 190. FEET
CAUSTIC DEPTH = 29.4 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	PIRISE	PM	I	IC		FIRISE	FP	FI	FIC	FE
N2	27.25	40.8	*	9.5	46.0	.00353	.00353	0.091	0.35	1.75	1.17	1.17	2.89
N1	27.67	48.8	*	7.0	55.0	.00349	.00349	0.107	0.26	2.00	1.15	1.15	3.40
C	28.00	58.7	*	25.5	63.5	.00375	.00375	0.130	0.94	2.40	1.24	1.24	4.13
G	28.25	66.5	*	29.0	73.0	.00367	.00367	0.142	1.08	2.73	1.21	1.21	4.51
A	28.42	76.0	*	32.0	88.0	.00379	.00379	0.170	1.18	3.23	1.25	1.25	5.39
D	28.58	85.7	*	38.3	97.0	.00374	.00374	0.184	1.43	3.57	1.23	1.23	5.84
B	28.75	100.	*	44.5	116.	.00372	.00372	0.206	1.64	4.18	1.23	1.23	6.54
E	28.92	112.	*	55.7	131.	.00369	.00369	0.226	2.10	4.90	1.22	1.22	7.18
H	29.17	127.	*	127.	160.	.00346	.00346	0.266	4.73	5.80	1.14	1.14	8.45
J	29.50		*										
K	29.92		106.		122.	.00377	.00377	0.221		4.60	1.24	1.24	7.02
L	30.42	45.2	79.5	45.2	55.0	.00409	.00409	0.202	1.69	3.25	1.35	1.35	6.42
M	31.00	45.1	56.4	45.1	61.5	.00404	.00404	0.159	1.68	2.27	1.33	1.33	5.09
N3	31.67	42.1	42.1	42.1	46.0	.00396	.00396	0.124	1.56	1.75	1.31	1.31	3.93
N4	32.50	40.4	27.8	40.4	44.0	.00415	.00415	0.105	1.50	1.65	1.37	1.37	3.33

SHOT NO. 1107
CHARGE WEIGHT = 0.122 POUNDS
CHARGE DEPTH = 50. FEET
HORIZONTAL RANGE = 300. FEET
CAUSTIC DEPTH = 28.8 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	PIRISE	PM	I	IC		FIRISE	FP	FI	FIC	FE
N2	27.17	24.4	*	17.9	26.5	.00230	.00140	0.025	1.12	1.70	1.17	0.71	2.05
N1	27.58	31.0	*	23.5	35.5	.00233	.00143	0.030	1.48	2.20	1.18	0.73	2.47
C	27.92	43.5	*	33.0	49.5	.00278	.00171	0.048	2.07	3.20	1.41	0.87	3.96
G	28.17	48.7	*	37.8	57.0	.00281	.00172	0.052	2.35	3.50	1.43	0.87	4.28
A	28.33	56.3	*	41.6	64.0	.00292	.00180	0.063	2.52	3.80	1.48	0.91	5.18
D	28.50	61.9	*	48.6	73.5	.00320	.00200	0.077	3.05	4.65	1.62	1.02	6.34
B	28.67	64.6	*	51.8	77.5	.00300	.00192	0.079	3.25	4.70	1.52	0.97	6.50
E	28.83	66.8	*	54.5	81.0	.00293	.00186	0.081	3.42	5.10	1.49	0.94	6.56
H	29.08	63.0	*	53.5	74.0	.00282	.00201	0.083	3.35	4.60	1.43	1.02	6.83
J	29.42	59.5	*	50.5	69.0	.00288	.00215	0.084	3.17	4.45	1.46	1.09	6.91
K	29.83	35.4	53.7	26.7	62.5	.00288	.00227	0.079	1.74	3.85	1.46	1.15	6.50
L	30.33	33.3	51.3	27.3	58.5	.00305	.00271	0.084	1.61	3.60	1.55	1.38	6.91
M	30.92	32.6	47.6	26.4	53.5	.00306	.00278	0.080	1.64	3.45	1.55	1.41	6.58
N3	31.58	29.7	42.0	24.6	47.0	.00328	.00315	0.079	1.54	2.95	1.67	1.60	6.50
N4	32.42	22.8	39.7	21.7	46.0	.00311	.00307	0.067	1.37	3.00	1.58	1.56	5.51

TABLE I CONTINUED

SHOT NO. 1108
CHARGE WEIGHT = 0.122 POUNDS
CHARGE DEPTH = 50. FEET
HORIZONTAL RANGE = 300. FEET
CAUSTIC DEPTH = 29.2 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	PIRISE	PM	I	IC		FIRISE	FP	FI	FIC	FE
N2	27.17	20.8	*	11.2	22.3	.00218	.00118	0.022	0.71	1.40	1.11	0.60	1.81
N1	27.58	26.5	*	14.3	28.5	.00239	.00115	0.026	0.90	1.80	1.21	0.58	2.14
C	27.92	34.7	*	20.3	37.5	.00273	.00146	0.040	1.26	2.38	1.39	0.74	3.29
G	28.17	38.2	*	23.8	43.0	.00248	.00135	0.038	1.51	2.70	1.26	0.69	3.13
A	28.33	45.7	*	30.3	51.0	.00290	.00157	0.053	1.89	3.20	1.47	0.80	4.26
D	28.50	47.7	*	32.4	57.5	.00261	.00145	0.048	2.00	3.45	1.33	0.74	3.95
B	28.67	54.7	*	39.7	62.0	.00285	.00168	0.062	2.50	3.85	1.45	0.85	5.10
E	28.83	62.2	*	45.7	74.0	.00293	.00172	0.067	2.85	4.60	1.49	0.87	5.51
H	29.08	61.0	*	50.7	75.0	.00266	.00176	0.069	3.15	4.55	1.35	0.89	5.68
J	29.42	65.3	*	56.5	75.0	.00293	.00200	0.087	3.55	4.95	1.49	1.02	7.16
K	29.83		56.2		64.5	.00280	.00208	0.076		4.10	1.42	1.06	6.25
L	30.33	37.7	53.2	30.6	60.5	.00298	.00235	0.083	1.91	3.75	1.51	1.19	6.83
M	30.92	34.0	46.4	26.9	55.0	.00288	.00244	0.075	1.69	3.30	1.46	1.24	6.17
N3	31.58	30.9	42.0	25.6	48.0	.00303	.00264	0.079	1.60	3.00	1.54	1.34	6.50
N4	32.42	27.4	37.6	24.0	43.5	.00315	.00311	0.072	1.52	2.73	1.60	1.58	5.92

SHOT NO. 1109
CHARGE WEIGHT = 0.122 POUNDS
CHARGE DEPTH = 35. FEET
HORIZONTAL RANGE = 300. FEET
CAUSTIC DEPTH = 40.2 FEET

GAGE	DEPTH	PRESSURES MEASURED AT PEAKS				IMPULSE		$\int p^2\,dt$	AMPLIFICATION FACTORS				
		P1	P2	PIRISE	PM	I	IC		FIRISE	FP	FI	FIC	FE
N2	38.92	42.0	*	30.7	48.5	.00166	.00141	0.038	1.88	3.00	0.84	0.72	3.13
N1	39.33	45.4	*	35.5	55.0	.00156	.00128	0.036	2.24	3.60	0.79	0.65	2.97
C	39.67	55.9	*	48.2	70.0	.00268	.00162	0.055	3.02	4.30	1.36	0.82	4.53
G	39.92	56.0	*	50.4	68.0	.00230	.00143	0.051	3.14	4.40	1.17	0.73	4.20
A	40.08	59.3	*	52.8	73.0	.00260	.00157	0.059	3.30	5.00	1.32	0.80	4.85
D	40.25	62.0	*	54.3	82.0	.00285	.00169	0.065	3.40	4.90	1.45	0.86	5.35
B	40.42	60.3	*	54.0	74.0	.00280	.00190	0.069	3.37	4.70	1.42	0.96	5.68
E	40.58	58.6	*	52.0	69.0	.00265	.00173	0.063	3.26	4.50	1.35	0.88	5.19
H	40.83	55.2	*	48.0	64.0	.00286	.00187	0.071	3.02	4.00	1.45	0.95	5.85
J	41.17	51.6	*	45.2	62.0	.00286	.00196	0.066	2.83	3.80	1.45	1.00	5.44
K	41.58	35.0	48.8	28.3	56.0	.00281	.00202	0.065	1.74	3.50	1.43	1.03	5.35
L	42.08	35.4	45.6	29.2	53.0	.00300	.00225	0.072	1.80	3.31	1.52	1.14	5.92
M	42.67	32.5	41.8	27.3	48.0	.00284	.00226	0.066	1.70	3.01	1.44	1.15	5.43
N3	43.33	31.7	42.4	26.2	50.0	.00323	.00268	0.077	1.64	3.12	1.64	1.36	6.34
N4	44.17	29.8	38.9	23.4	44.5	.00368	.00318	0.083	1.46	2.78	1.87	1.61	6.83

TABLE II TABULATION OF VELOCITY PROFILE DATA

SHOT NO. 1078
DATE 8/18/64
TIME OF FIRING 1419
TIME OF PROFILE 1405

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4910.02	
0.25		4902.48
2.50	4898.12	
5.00	4896.48	
10.00	4895.54	4895.39
12.50	4894.81	
15.00	4889.72	4892.06
20.00	4801.63	4799.73
25.00	4747.86	
30.00	4724.30	
35.00	4715.81	4718.66
40.00	4710.94	
45.00	4709.69	
50.00	4708.99	4710.16
55.00	4708.99	
65.00	4703.89	4706.01

SHOT NO. 1078
DATE 8/18/64
TIME OF FIRING 1419
TIME OF PROFILE 1410

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4910.02	
0.25		4902.99
2.50	4897.87	
5.00	4896.48	
10.00	4895.54	4895.13
12.50	4894.81	
15.00	4890.76	4891.54
20.00	4801.63	4799.08
25.00	4747.86	
30.00	4724.30	
35.00	4715.81	4717.89
40.00	4710.94	
45.00	4709.69	
50.00	4708.21	4709.38
55.00	4708.21	
65.00	4703.89	4706.01

SHOT NO. 1078
DATE 8/18/64
TIME OF FIRING 1419
TIME OF PROFILE 1419

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4909.53	
0.25		
2.50	4898.63	
5.00	4896.48	
10.00	4895.80	
12.50	4895.07	
15.00	4890.50	
20.00		
25.00		
30.00		
35.00		
40.00		
45.00		
50.00		
55.00		
65.00		

SHOT NO. 1079
DATE 8/20/64
TIME OF FIRING 1055
TIME OF PROFILE 1000

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4893.94	
0.25		4891.77
2.50	4891.96	
5.00	4892.37	
10.00	4891.93	4891.51
12.50	4891.71	
15.00	4889.72	4890.50
20.00	4802.93	4803.65
25.00	4749.31	
30.00	4726.58	
35.00	4718.12	4719.43
40.00	4714.81	
45.00	4711.25	
50.00	4710.55	4710.94
55.00	4710.55	
65.00	4709.38	4711.48

TABLE II CONTINUED

SHOT NO. 1079
DATE 8/20/64
TIME OF FIRING 1055
TIME OF PROFILE 1038

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4893.42	
0.25		4894.35
2.50	4893.00	
5.00	4892.37	
10.00	4891.41	4891.51
12.50	4890.67	
15.00	4890.24	4889.98
20.00	4801.63	4803.00
25.00	4748.59	
30.00	4725.06	
35.00	4716.58	4719.43
40.00	4712.49	
45.00	4710.47	
50.00	4709.77	4710.16
55.00	4709.77	
65.00	4707.03	4709.14

SHOT NO. 1080
DATE 8/20/64
TIME OF FIRING 1518
TIME OF PROFILE 1502

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4913.91	
0.25		4907.96
2.50	4898.12	
5.00	4893.40	
10.00	4892.19	4892.55
12.50	4891.45	
15.00	4888.15	4889.46
20.00	4802.93	4802.35
25.00	4747.13	
30.00	4721.26	
35.00	4714.27	4715.58
40.00	4710.16	
45.00	4709.69	
50.00	4708.99	4709.38
55.00	4708.21	
65.00	4703.89	4709.14

SHOT NO. 1080
DATE 8/20/64
TIME OF FIRING 1518
TIME OF PROFILE 1519

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4914.88	
0.25		4908.20
2.50	4899.39	
5.00	4893.92	
10.00	4893.48	4893.59
12.50	4892.75	
15.00	4889.20	4891.02
20.00	4804.88	4810.74
25.00	4744.94	
30.00	4724.30	
35.00	4715.81	4719.43
40.00	4710.94	
45.00	4709.69	
50.00	4708.99	4710.16
55.00	4708.99	
65.00	4704.68	4710.70

SHOT NO. 1081
DATE 8/21/64
TIME OF FIRING 1555
TIME OF PROFILE 1536

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4919.66	
0.25		4925.21
2.50	4903.67	
5.00	4899.03	
10.00	4896.56	4897.18
12.50	4894.81	
15.00	4889.72	4889.98
20.00	4806.82	4801.69
25.00	4749.31	
30.00	4726.58	
35.00	4718.12	4719.43
40.00	4714.81	
45.00	4711.25	
50.00	4711.33	4710.16
55.00	4710.55	
65.00	4709.38	4710.70

TABLE II CONTINUED

SHOT NO. 1081
DATE 8/21/64
TIME OF FIRING 1555
TIME OF PROFILE 1600

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4924.37	
0.25		4929.37
2.50	4906.66	
5.00	4901.05	
10.00	4896.56	4897.18
12.50	4895.32	
15.00	4889.72	4889.98
20.00	4806.82	4804.30
25.00	4750.76	
30.00	4726.58	
35.00	4718.12	4719.43
40.00	4714.81	
45.00	4711.25	
50.00	4711.33	4710.94
55.00	4710.55	
65.00	4709.38	4710.70

SHOT NO. 1082
DATE 8/24/64
TIME OF FIRING 1202
TIME OF PROFILE 1105

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4919.19	
0.25		4913.33
2.50	4911.57	
5.00	4910.00	
10.00	4900.63	4904.25
12.50	4897.88	
15.00	4889.72	4889.46
20.00	4808.11	4808.17
25.00	4749.31	
30.00	4726.58	
35.00	4718.12	4720.19
40.00	4715.58	
45.00	4712.80	
50.00	4710.55	4712.49
55.00	4710.55	
65.00	4709.38	4710.70

SHOT NO. 1082
DATE 8/24/64
TIME OF FIRING 1202
TIME OF PROFILE 1145

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4921.55	
0.25		4912.85
2.50	4912.55	
5.00	4910.49	
10.00	4900.12	4904.25
12.50	4898.90	
15.00	4889.72	4889.98
20.00	4808.11	4806.88
25.00	4748.59	
30.00	4726.58	
35.00	4718.12	4719.43
40.00	4714.81	
45.00	4711.25	
50.00	4710.55	4710.94
55.00	4710.55	
65.00	4708.60	4710.70

SHOT NO. 1083
DATE 8/24/64
TIME OF FIRING 1527
TIME OF PROFILE 1315

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4922.02	
0.25		4919.57
2.50	4913.03	
5.00	4910.00	
10.00	4901.64	4904.25
12.50	4898.39	
15.00	4893.36	4890.50
20.00	4805.53	4807.53
25.00	4749.31	
30.00	4725.06	
35.00	4715.81	4719.43
40.00	4710.94	
45.00	4710.47	
50.00	4709.77	4710.16
55.00	4709.77	
65.00	4707.03	4709.92

TABLE II CONTINUED

SHOT NO. 1083
DATE 8/24/64
TIME OF FIRING 1527
TIME OF PROFILE 1445

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4926.23	
0.25		4928.91
2.50	4913.03	
5.00	4910.98	
10.00	4902.64	4905.24
12.50	4899.41	
15.00	4890.24	4889.98
20.00	4808.75	4808.17
25.00	4748.59	
30.00	4725.06	
35.00	4717.35	4719.43
40.00	4710.94	
45.00	4710.47	
50.00	4709.77	4710.16
55.00	4708.99	
65.00	4707.03	4709.92

SHOT NO. 1083
DATE 8/24/64
TIME OF FIRING 1527
TIME OF PROFILE 1530

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4932.65	
0.25		4928.91
2.50	4914.48	
5.00	4911.47	
10.00	4903.65	4904.74
12.50	4900.42	
15.00	4889.72	4891.02
20.00	4806.75	4804.30
25.00	4750.04	
30.00	4726.58	
35.00	4718.12	4720.19
40.00	4713.27	
45.00	4711.25	
50.00	4709.77	4710.16
55.00	4709.77	
65.00	4709.38	4709.92

SHOT NO. 1084
DATE 8/25/64
TIME OF FIRING 1209
TIME OF PROFILE 1100

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4918.71	
0.25		4912.36
2.50	4912.06	
5.00	4910.98	
10.00	4904.65	4906.24
12.50	4900.92	
15.00	4888.15	4889.46
20.00	4807.46	4808.81
25.00	4749.31	
30.00	4726.58	
35.00	4718.12	4719.43
40.00	4710.94	
45.00	4710.47	
50.00	4710.55	4710.94
55.00	4709.77	
65.00	4707.82	4709.92

SHOT NO. 1084
DATE 8/25/64
TIME OF FIRING 1209
TIME OF PROFILE 1214

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4922.96	
0.25		4914.78
2.50	4912.06	
5.00	4910.98	
10.00	4903.65	4902.24
12.50	4900.92	
15.00	4888.68	4887.89
20.00	4808.75	4820.23
25.00	4749.31	
30.00	4726.58	
35.00	4718.12	4719.43
40.00	4710.94	
45.00	4710.47	
50.00	4710.55	4710.16
55.00	4709.77	
65.00	4709.38	4710.70

TABLE II CONTINUED

SHOT NO. 1085
DATE 8/25/64
TIME OF FIRING 1516
TIME OF PROFILE 1333

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4920.08	
0.25		4923.81
2.50	4914.00	
5.00	4912.44	
10.00	4905.14	4906.24
12.50	4900.92	
15.00	4889.20	4888.94
20.00	4808.11	4807.53
25.00	4755.80	
30.00	4727.33	
35.00	4718.12	4719.43
40.00	4710.94	
45.00	4710.47	
50.00	4710.55	4710.16
55.00	4710.55	
65.00	4709.38	4710.70

SHOT NO. 1085
DATE 8/25/64
TIME OF FIRING 1516
TIME OF PROFILE 1457

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4928.54	
0.25		4925.21
2.50	4915.93	
5.00	4911.95	
10.00	4904.65	4905.74
12.50	4900.42	
15.00	4900.51	4890.50
20.00	4808.11	4803.00
25.00	4750.04	
30.00	4726.58	
35.00	4717.35	4719.43
40.00	4712.49	
45.00	4710.47	
50.00	4708.99	4710.16
55.00	4708.99	
65.00	4706.25	4710.70

SHOT NO. 1086
DATE [illegible] 26/64
TIME OF FIRING 1405
TIME OF PROFILE 1238

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4918.71	
0.25		4916.23
2.50	4914.00	
5.00	4913.90	
10.00	4907.13	4907.23
12.50	4901.43	
15.00	4889.20	4889.46
20.00	4810.67	4808.17
25.00	4750.04	
30.00	4727.33	
35.00	4718.12	4720.19
40.00	4714.81	
45.00	4711.25	
50.00	4710.55	4710.94
55.00	4710.55	
65.00	4709.38	4710.70

SHOT NO. 1086
DATE 8/26/64
TIME OF FIRING 1405
TIME OF PROFILE 1350

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4922.02	
0.25		4919.09
2.50	4915.45	
5.00	4913.90	
10.00	4906.63	4907.23
12.50	4901.43	
15.00	4889.72	4889.98
20.00	4814.49	4808.17
25.00	4750.76	
30.00	4726.58	
35.00	4718.12	4719.43
40.00	4712.49	
45.00	4710.47	
50.00	4710.55	4710.16
55.00	4709.77	
65.00	4705.47	4710.70

TABLE II CONTINUED

SHOT NO. 1086
DATE 8/26/64
TIME OF FIRING 1405
TIME OF PROFILE 1409

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4923.90	
0.25		4918.14
2.50	4915.45	
5.00	4913.90	
10.00	4907.13	4907.23
12.50	4902.43	
15.00	4889.20	4888.94
20.00	4811.31	4808.17
25.00	4752.93	
30.00	4726.58	
35.00	4718.12	4719.43
40.00	4713.27	
45.00	4711.25	
50.00	4710.55	4710.94
55.00	4709.77	
65.00	4707.03	4709.92

SHOT NO. 1087
DATE 8/27/64
TIME OF FIRING 1113
TIME OF PROFILE 1055

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4911.49	
0.25		4911.39
2.50	4912.55	
5.00	4910.98	
10.00	4910.57	4910.67
12.50	4905.93	
15.00	4890.24	4891.02
20.00	4814.49	4812.65
25.00	4755.08	
30.00	4730.35	
35.00	4718.89	4720.96
40.00	4715.58	
45.00	4712.80	
50.00	4711.33	4714.81
55.00	4710.55	
65.00	4710.16	4713.03

SHOT NO. 1088
DATE 8/27/64
TIME OF FIRING 1541
TIME OF PROFILE 1535

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4913.91	
0.25		4915.27
2.50	4913.03	
5.00	4911.71	
10.00	4910.57	4910.67
12.50	4904.69	4904.74
15.00	4889.20	4889.46
20.00	4813.22	4812.65
25.00	4752.93	
30.00	4727.33	
35.00	4718.12	4719.43
40.00	4714.04	
45.00	4711.25	
50.00	4710.55	4710.16
55.00	4709.77	
65.00	4706.25	4709.92

SHOT NO. 1089
DATE 8/28/64
TIME OF FIRING 1504
TIME OF PROFILE 1451

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4911.00	
0.25		4911.88
2.50	4911.57	
5.00	4910.00	
10.00	4910.08	4909.20
12.50	4904.94	4906.23
15.00	4889.20	4889.98
20.00	4812.59	4813.92
25.00	4752.93	
30.00	4728.09	
35.00	4718.12	4720.19
40.00	4713.27	
45.00	4711.25	
50.00	4710.55	4710.94
55.00	4710.55	
65.00	4709.38	4710.70

TABLE II CONTINUED

SHOT NO. 1090
DATE 8/31/64
TIME OF FIRING 1130
TIME OF PROFILE 1050

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4918.24	
0.25		4915.75
2.50	4916.41	
5.00	4915.34	
10.00	4913.01	4912.62
12.50	4908.90	4908.21
15.00	4891.80	4893.62
20.00	4819.54	4820.85
25.00	4757.95	
30.00	4733.34	
35.00	4722.71	4725.52
40.00	4717.89	
45.00	4715.12	
50.00	4712.88	4715.58
55.00	4711.33	
65.00	4710.16	4711.48

SHOT NO. 1090
DATE 8/31/64
TIME OF FIRING 1130
TIME OF PROFILE 1120

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4919.66	
0.25		4915.75
2.50	4915.45	
5.00	4914.86	
10.00	4912.04	4911.65
12.50	4907.42	4907.71
15.00	4892.32	4889.98
20.00	4815.76	4820.23
25.00	4756.52	
30.00	4731.10	
35.00	4719.66	4723.24
40.00	4715.58	
45.00	4712.80	
50.00	4711.33	4712.49
55.00	4710.55	
65.00	4710.16	4710.70

SHOT NO. 1091
DATE 8/31/64
TIME OF FIRING 1522
TIME OF PROFILE 1420

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4933.10	
0.25		4923.81
2.50	4917.84	
5.00	4916.31	
10.00	4914.95	4914.08
12.50	4910.37	4911.15
15.00	4892.84	4895.16
20.00	4818.28	4825.82
25.00	4757.23	
30.00	4734.09	
35.00	4723.47	4726.28
40.00	4718.66	
45.00	4713.58	
50.00	4712.88	4715.58
55.00	4711.33	
65.00	4710.94	4711.48

SHOT NO. 1091
DATE 8/31/64
TIME OF FIRING 1522
TIME OF PROFILE 1515

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4934.00	
0.25		4924.74
2.50	4917.37	
5.00	4915.34	
10.00	4913.01	4911.65
12.50	4907.42	4907.71
15.00	4891.28	4890.50
20.00	4815.13	4820.23
25.00	4756.52	
30.00	4728.09	
35.00	4718.89	4720.96
40.00	4712.49	
45.00	4711.25	
50.00	4710.55	4710.94
55.00	4710.55	
65.00	4709.38	4710.70

TABLE 11 CONTINUED

SHOT NO. 1092
DATE 9/ 1/64
TIME OF FIRING 1048
TIME OF PROFILE 1040

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4915.36	
0.25		4914.30
2.50	4914.97	
5.00	4914.38	
10.00	4913.98	4913.11
12.50	4907.42	4907.71
15.00	4889.72	4889.98
20.00	4815.13	4820.23
25.00	4756.52	
30.00	4728.09	
35.00	4718.89	4720.19
40.00	4713.27	
45.00	4711.25	
50.00	4710.55	4710.94
55.00	4710.55	
65.00	4709.38	4710.70

SHOT NO. 1093
DATE 9/ 1/64
TIME OF FIRING 1449
TIME OF PROFILE 1438

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4922.02	
0.25		4916.71
2.50	4917.84	
5.00	4915.34	
10.00	4914.95	4913.59
12.50	4907.91	4910.66
15.00	4892.32	4891.54
20.00	4815.76	4822.10
25.00	4756.52	
30.00	4730.35	
35.00	4718.89	4721.72
40.00	4714.04	
45.00	4712.80	
50.00	4710.55	4710.94
55.00	4709.77	
65.00	4708.60	4710.70

SHOT NO. 1093
DATE 9/ 1/64
TIME OF FIRING 1449
TIME OF PROFILE 1450

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4920.61	
0.25		4917.19
2.50	4917.84	
5.00	4915.83	
10.00	4914.95	4914.08
12.50	4908.90	4894.61
15.00	4892.84	4884.19
20.00	4815.13	4793.80
25.00	4756.52	
30.00	4727.33	
35.00	4718.89	4720.96
40.00	4714.81	
45.00	4711.25	
50.00	4710.55	4710.94
55.00	4709.77	
65.00	4708.60	

SHOT NO. 1093
DATE 9/ 1/64
TIME OF FIRING 1449
TIME OF PROFILE 1450

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17		
0.25		
2.50		
5.00		
10.00		
12.50		4902.74
15.00		
20.00		4830.13
25.00		
30.00		
35.00		
40.00		
45.00		
50.00		
55.00		
65.00		4725.30

TABLE II CONTINUED

SHOT NO. 1094
DATE 9/ 2/64
TIME OF FIRING 1124
TIME OF PROFILE 1100

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4911.49	
0.25		4910.90
2.50	4912.06	
5.00	4910.49	
10.00	4910.57	4792.97
12.50	4909.39	4909.68
15.00	4890.24	4891.02
20.00	4815.76	4818.97
25.00	4756.52	
30.00	4732.59	
35.00	4720.42	4722.48
40.00	4717.12	
45.00	4712.80	
50.00	4710.55	4713.27
55.00	4710.55	
65.00	4710.16	4711.48

SHOT NO. 1095
DATE 9/ 2/64
TIME OF FIRING 1409
TIME OF PROFILE 1403

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4919.66	
0.25		4917.66
2.50	4914.00	
5.00	4912.44	
10.00	4911.06	4911.16
12.50	4910.86	4911.15
15.00	4893.87	4893.62
20.00	4817.65	4815.19
25.00	4757.95	
30.00	4734.09	
35.00	4722.71	4723.24
40.00	4717.89	
45.00	4713.58	
50.00	4711.33	4716.36
55.00	4710.55	
65.00	4710.16	4713.03

SHOT NO. 1096
DATE 9/ 3/64
TIME OF FIRING 1355
TIME OF PROFILE 1340

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4918.71	
0.25		4913.82
2.50	4910.11	
5.00	4909.51	
10.00	4905.64	4907.23
12.50	4906.43	4906.72
15.00	4894.90	4897.72
20.00	4818.28	4818.97
25.00	4757.23	
30.00	4731.85	
35.00	4720.42	4722.48
40.00	4716.35	
45.00	4711.25	
50.00	4710.55	4712.49
55.00	4710.55	
65.00	4710.16	4711.48

SHOT NO. 1097
DATE 9/ 4/64
TIME OF FIRING 1223
TIME OF PROFILE 1208

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4913.91	
0.25		4907.46
2.50	4908.63	
5.00	4904.56	
10.00	4903.65	4905.74
12.50	4905.93	4905.23
15.00	4901.52	4901.77
20.00	4821.41	4821.48
25.00	4761.50	
30.00	4733.34	
35.00	4721.95	4724.76
40.00	4717.89	
45.00	4713.58	
50.00	4711.33	4715.58
55.00	4711.33	
65.00	4710.16	4711.48

TABLE II CONTINUED

SHOT NO. 1098
DATE 9/ 4/64
TIME OF FIRING 1540
TIME OF PROFILE 1530

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4924.83	
0.25		4919.57
2.50	4909.62	
5.00	4906.06	
10.00	4903.65	4906.24
12.50	4905.43	4905.73
15.00	4901.02	4892.06
20.00	4819.54	4815.19
25.00	4757.23	
30.00	4733.34	
35.00	4719.66	4721.72
40.00	4717.12	
45.00	4711.25	
50.00	4710.55	4713.27
55.00	4710.55	
65.00	4710.16	4711.48

SHOT NO. 1098
DATE 9/ 4/64
TIME OF FIRING 1540
TIME OF PROFILE 1535

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4927.62	
0.25		4919.57
2.50	4911.08	
5.00	4908.03	
10.00	4904.65	4906.24
12.50	4905.43	4905.73
15.00	4899.50	4893.10
20.00	4822.04	4818.97
25.00	4762.92	
30.00	4733.34	
35.00	4719.66	4721.72
40.00	4716.35	
45.00	4711.25	
50.00	4710.55	4712.49
55.00	4710.55	
65.00	4710.16	4711.48

SHOT NO. 1099
DATE 9/ 8/64
TIME OF FIRING 1443
TIME OF PROFILE 1430

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4911.00	
0.25		4914.78
2.50	4902.67	
5.00	4899.54	
10.00	4899.11	4900.73
12.50	4899.41	4899.71
15.00	4898.99	4898.74
20.00	4826.38	4827.06
25.00	4763.62	
30.00	4734.83	
35.00	4724.23	4726.28
40.00	4718.66	
45.00	4715.89	
50.00	4715.20	4717.89
55.00	4713.65	
65.00	4710.94	4716.13

SHOT NO. 1100
DATE 9/ 9/64
TIME OF FIRING 1118
TIME OF PROFILE 1058

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4903.08	
0.25		4899.46
2.50	4900.66	
5.00	4898.01	
10.00	4898.10	4898.71
12.50	4897.88	4897.68
15.00	4897.46	4896.70
20.00	4826.38	4826.44
25.00	4763.62	
30.00	4734.83	
35.00	4724.99	4726.28
40.00	4718.66	
45.00	4717.43	
50.00	4713.65	4717.13
55.00	4712.88	
65.00	4710.94	4713.03

TABLE II CONTINUED

SHOT NO. 1101
DATE 9/ 9/64
TIME OF FIRING 1448
TIME OF PROFILE 1405

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4916.32	
0.25		4919.09
2.50	4901.67	
5.00	4898.52	
10.00	4898.60	4900.23
12.50	4898.90	4898.70
15.00	4897.97	4896.70
20.00	4826.38	4824.59
25.00	4765.03	
30.00	4734.09	
35.00	4723.47	4726.28
40.00	4718.66	
45.00	4716.66	
50.00	4712.88	4717.13
55.00	4711.33	
65.00	4710.94	4713.03

SHOT NO. 1101
DATE 9/ 9/64
TIME OF FIRING 1448
TIME OF PROFILE 1430

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4918.24	
0.25		4914.78
2.50	4901.67	
5.00	4898.52	
10.00	4898.60	4899.21
12.50	4898.90	4898.19
15.00	4896.44	4896.19
20.00	4825.14	4827.06
25.00	4763.62	
30.00	4732.59	
35.00	4720.42	4721.72
40.00	4718.66	
45.00	4712.80	
50.00	4711.33	4712.49
55.00	4710.55	
65.00	4710.16	4710.70

SHOT NO. 1102
DATE 9/10/64
TIME OF FIRING 1142
TIME OF PROFILE 1130

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4902.08	
0.25		4900.97
2.50	4901.16	
5.00	4897.50	
10.00	4897.59	4898.20
12.50	4897.88	4895.63
15.00	4897.46	4895.16
20.00	4822.04	4827.67
25.00	4764.33	
30.00	4734.09	
35.00	4724.23	4725.52
40.00	4718.66	
45.00	4714.35	
50.00	4711.33	4712.49
55.00	4711.33	
65.00	4710.16	4710.70

SHOT NO. 1103
DATE 9/10/64
TIME OF FIRING 1458
TIME OF PROFILE 1408

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4917.28	
0.25		4911.39
2.50	4901.67	
5.00	4898.52	
10.00	4898.60	4899.21
12.50	4898.90	4898.70
15.00	4897.97	4897.72
20.00	4827.61	4827.67
25.00	4765.03	
30.00	4734.83	
35.00	4724.23	4726.28
40.00	4718.66	
45.00	4714.35	
50.00	4711.33	4714.81
55.00	4711.33	
65.00	4710.16	4711.48

TABLE II CONTINUED

SHOT NO. 1103
DATE 9/10/64
TIME OF FIRING 1458
TIME OF PROFILE 1437

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4916.80	
0.25		4915.75
2.50	4903.17	
5.00	4898.52	
10.00	4898.10	4898.71
12.50	4897.88	4897.68
15.00	4897.46	4895.67
20.00	4828.23	4827.06
25.00	4762.92	
30.00	4734.09	
35.00	4720.42	4725.52
40.00	4717.12	
45.00	4712.80	
50.00	4711.33	4712.49
55.00	4710.55	
65.00	4710.16	4711.48

SHOT NO. 1104
DATE 9/11/64
TIME OF FIRING 1101
TIME OF PROFILE 1010

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4909.53	
0.25		4907.96
2.50	4908.63	
5.00	4902.06	
10.00	4899.62	4900.73
12.50	4899.41	4899.20
15.00	4897.97	4898.23
20.00	4828.23	4828.29
25.00	4764.33	
30.00	4735.58	
35.00	4722.71	4726.28
40.00	4718.66	
45.00	4716.66	
50.00	4712.88	4717.13
55.00	4711.33	
65.00	4710.94	4713.03

SHOT NO. 1104
DATE 9/11/64
TIME OF FIRING 1101
TIME OF PROFILE 1048

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4910.51	
0.25		4909.92
2.50	4908.63	
5.00	4902.56	
10.00	4899.62	4900.73
12.50	4899.41	4899.71
15.00	4897.97	4898.23
20.00	4828.23	4827.67
25.00	4763.62	
30.00	4735.58	
35.00	4724.99	4726.28
40.00	4719.43	
45.00	4716.66	
50.00	4712.88	4717.13
55.00	4711.33	
65.00	4710.94	4713.03

SHOT NO. 1105
DATE 9/11/64
TIME OF FIRING 1258
TIME OF PROFILE 1246

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4914.88	
0.25		4911.39
2.50	4908.14	
5.00	4902.31	
10.00	4899.11	4900.48
12.50	4899.41	4898.70
15.00	4897.21	4895.16
20.00	4824.52	4828.90
25.00	4764.33	
30.00	4734.09	
35.00	4723.47	4724.00
40.00	4718.66	
45.00	4715.12	
50.00	4712.88	4714.04
55.00	4711.33	
65.00	4709.38	4711.48

TABLE II CONTINUED

SHOT NO. 1105
DATE 9/11/64
TIME OF FIRING 1258
TIME OF PROFILE 1250

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4916.32	
0.25		4910.90
2.50	4907.65	
5.00	4902.56	
10.00	4899.11	4900.23
12.50	4899.41	4899.20
15.00	4896.44	4895.93
20.00	4828.23	4827.67
25.00	4764.33	
30.00	4734.09	
35.00	4724.23	4724.00
40.00	4718.66	
45.00	4714.35	
50.00	4712.88	4714.04
55.00	4711.33	
65.00	4709.38	4711.48

SHOT NO. 1106
DATE 9/11/64
TIME OF FIRING 1429
TIME OF PROFILE 1411

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4923.90	
0.25		4916.23
2.50	4910.11	
5.00	4903.06	
10.00	4899.62	4900.73
12.50	4899.41	4899.20
15.00	4898.23	4897.72
20.00	4828.84	4828.90
25.00	4765.03	
30.00	4734.09	
35.00	4723.47	4726.28
40.00	4718.66	
45.00	4716.66	
50.00	4714.04	4714.81
55.00	4712.88	
65.00	4709.38	4711.48

SHOT NO. 1106
DATE 9/11/64
TIME OF FIRING 1429
TIME OF PROFILE 1415

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4923.90	
0.25		4916.23
2.50	4909.13	
5.00	4903.06	
10.00	4900.12	4901.24
12.50	4900.42	4900.72
15.00	4897.97	4897.72
20.00	4823.90	4828.29
25.00	4764.33	
30.00	4734.09	
35.00	4722.71	4727.03
40.00	4718.66	
45.00	4715.12	
50.00	4713.65	4714.81
55.00	4712.88	
65.00	4710.16	4713.03

SHOT NO. 1106
DATE 9/11/64
TIME OF FIRING 1429
TIME OF PROFILE 1418

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4923.43	
0.25		4915.27
2.50	4909.13	
5.00	4903.06	
10.00	4900.12	4900.73
12.50	4900.42	4899.71
15.00	4898.48	4896.70
20.00	4823.28	4827.06
25.00	4765.03	
30.00	4734.09	
35.00	4721.95	4727.03
40.00	4718.66	
45.00	4715.12	
50.00	4712.88	4714.81
55.00	4711.33	
65.00	4710.16	4713.81

TABLE II CONTINUED

SHOT NO. 1107
DATE 9/14/64
TIME OF FIRING 1155
TIME OF PROFILE 1150

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4888.22	
0.25		4883.37
2.50	4885.68	
5.00	4882.91	
10.00	4882.46	4883.10
12.50	4882.77	4882.56
15.00	4882.86	4882.06
20.00	4832.51	4828.29
25.00	4765.03	
30.00	4734.83	
35.00	4724.23	4727.03
40.00	4718.66	
45.00	4713.58	
50.00	4713.65	4715.58
55.00	4712.88	
65.00	4710.16	4713.81

SHOT NO. 1107
DATE 9/14/64
TIME OF FIRING 1155
TIME OF PROFILE 1152

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4888.75	
0.25		4883.37
2.50	4885.68	
5.00	4882.91	
10.00	4882.46	4883.10
12.50	4882.77	4882.02
15.00	4882.86	4881.53
20.00	4832.20	4830.13
25.00	4765.73	
30.00	4734.09	
35.00	4724.23	4726.28
40.00	4718.66	
45.00	4715.12	
50.00	4713.65	4714.81
55.00	4712.88	
65.00	4710.16	4713.03

SHOT NO. 1108
DATE 9/14/64
TIME OF FIRING 1330
TIME OF PROFILE 1325

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4889.79	
0.25		4883.90
2.50	4886.21	
5.00	4883.45	
10.00	4883.00	4883.63
12.50	4882.77	4882.02
15.00	4882.86	4881.80
20.00	4829.45	4832.57
25.00	4765.73	
30.00	4734.09	
35.00	4723.47	4727.03
40.00	4718.66	
45.00	4715.12	
50.00	4713.65	4714.81
55.00	4712.88	
65.00	4710.16	4713.03

SHOT NO. 1108
DATE 9/14/64
TIME OF FIRING 1330
TIME OF PROFILE 1329

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4892.91	
0.25		4883.90
2.50	4886.48	
5.00	4883.98	
10.00	4883.00	4883.37
12.50	4883.30	4882.56
15.00	4883.40	4881.53
20.00	4830.07	4830.13
25.00	4765.38	
30.00	4735.58	
35.00	4724.23	47[illegible].03
40.00	4718.66	
45.00	4715.12	
50.00	4713.65	4714.81
55.00	4712.88	
65.00	4710.16	4713.03

TABLE II CONTINUED

SHOT NO. 1109
DATE 9/14/64
TIME OF FIRING 1513
TIME OF PROFILE 1505

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4892.39	
0.25		4888.64
2.50	4886.21	
5.00	4884.24	
10.00	4883.26	4883.63
12.50	4883.30	4882.56
15.00	4883.13	4882.06
20.00	4829.76	4828.29
25.00	4765.73	
30.00	4734.83	
35.00	4723.85	4725.52
40.00	4718.66	
45.00	4715.12	
50.00	4713.65	4714.81
55.00	4712.88	
65.00	4710.16	4713.03

SHOT NO. 0
DATE 9/15/64
TIME OF FIRING 0
TIME OF PROFILE 823

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4878.66	
0.25		4878.55
2.50	4880.36	
5.00	4879.71	
10.00	4878.71	4878.82
12.50	4878.48	4878.27
15.00	4878.58	4878.85
20.00	4831.29	4828.29
25.00	4765.73	
30.00	4736.32	
35.00	4725.75	4727.79
40.00	4719.43	
45.00	0.	
50.00	4712.88	4717.13
55.00	4712.88	
65.00	4710.16	4713.03

SHOT NO. 0
DATE 9/15/64
TIME OF FIRING 0
TIME OF PROFILE 1005

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4881.88	
0.25		4879.63
2.50	4880.90	
5.00	4879.71	
10.00	4878.71	4879.36
12.50	4878.48	4878.81
15.00	4878.58	4878.85
20.00	4831.29	4831.96
25.00	4765.73	
30.00	4735.58	
35.00	4724.99	4727.79
40.00	4719.43	
45.00	4717.43	
50.00	4712.88	4717.89
55.00	4712.88	
65.00	4710.94	4713.03

SHOT NO. 0
DATE 9/15/64
TIME OF FIRING 0
TIME OF PROFILE 1015

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4882.41	
0.25		4879.09
2.50	4880.36	
5.00	4879.71	
10.00	4878.71	4878.28
12.50	4878.48	4878.81
15.00	4878.58	4878.85
20.00	4831.29	4830.13
25.00	4765.73	
30.00	4735.58	
35.00	4724.99	4726.28
40.00	4719.43	
45.00	4717.43	
50.00	4712.88	4714.81
55.00	4712.88	
65.00	4710.16	4711.48

TABLE II CONTINUED

SHOT NO. 0
DATE 9/15/64
TIME OF FIRING 0
TIME OF PROFILE 1112

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4883.47	
0.25		4879.63
2.50	4880.90	
5.00	4880.24	
10.00	4878.71	4878.82
12.50	4879.02	4878.81
15.00	4878.58	4878.85
20.00	4833.11	4834.39
25.00	4768.54	
30.00	4735.58	
35.00	4724.99	4726.28
40.00	4718.66	
45.00	4715.89	
50.00	4712.88	4715.58
55.00	4712.88	
65.00	4710.16	4711.48

SHOT NO. 0
DATE 9/15/64
TIME OF FIRING 0
TIME OF PROFILE 1130

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4882.41	
0.25		4879.63
2.50	4880.90	
5.00	4880.24	
10.00	4878.71	4878.82
12.50	4878.48	4878.81
15.00	4878.58	4878.85
20.00	4830.68	4832.57
25.00	4767.14	
30.00	4737.07	
35.00	4724.99	4727.03
40.00	4719.43	
45.00	4716.66	
50.00	4712.88	4717.13
55.00	4712.88	
65.00	4710.16	4711.48

SHOT NO. 0
DATE 9/15/64
TIME OF FIRING 0
TIME OF PROFILE 1206

DEPTH (FT)	SOUND VELOCITY (FT/SEC) STA. 1	STA. 2
0.17	4888.22	
0.25		4884.96
2.50	4881.43	
5.00	4879.71	
10.00	4878.71	4878.82
12.50	4878.48	4878.27
15.00	4878.58	4878.31
20.00	4830.68	4832.57
25.00	4767.14	
30.00	4736.69	
35.00	4724.99	4727.03
40.00	4718.66	
45.00	4716.28	
50.00	4713.65	4714.81
55.00	4712.88	
65.00	4710.94	4713.03

TABLE III. MEASURED ARRIVAL ANGLES

Shot No.	Charge Depth (ft)	Horizontal Range (ft)	Approximate Gage String Depth (ft)		Caustic Depth (ft)	Measured Ray Angles (Degrees downward from horizontal)			
			Top Gage	Bottom Gage		Precursor	First Caustic-Related Arrival	Second Caustic-Related Arrival	Surface Reflection
1078	35	300	35.5	37	38.6	18	7	--	21
1079			37	39	38.6	16	5	--	21
1080			38	40	38.6	15	3	--	24
1081			37	40	37.0	17	3	9	21
1085			37	40	38.3	16	4	--	21
1093			37	40	42.4	16	5	--	21
1094			37	39	39.2	16	5	--	21
1095			38	41	41.1	19	9	--	21
1096			41	44	41.6	19	6	--	21
1097			40	46	42.4	19	9	--	21
1109			39	44	40.2	18	5	9	22
1089	35	230	33	36	33.9	--	9	18	28
1090			31	34	32.8	21	10	--	25
1099			34	39	34.7	--	--	--	21
1100			34	39	33.0	15	11	21	25
1102			32	37	33.5	19	6	13	25
1103	35	190	27	32	28.8	--	10	--	24
1104			28	33	29.3	--	8	15	24
1105			28	33	29.1	--	7	15	24
1106			27	33	29.4	--	10	16	--
1091	35	160	24.5	26	--	--	23	--	20
1092			24	27	--	--	28	35	27
1086	25	300	58	61	59.4	--	20	--	30
1087			58	61	59.3	--	--	--	30

TABLE III. MEASURED ARRIVAL ANGLES (continued)

Shot No.	Charge Depth (ft)	Horizontal Range (ft)	Approximate Gage String Depth (ft)		Caustic Depth (ft)	Measured Ray Angles (Degrees downward from horizontal)			
			Top Gage	Bottom Gage		Precursor	First Caustic-Related Arrival	Second Caustic-Related Arrival	Surface Reflection
1088	25	300	6	9	--	--	--	--	7
1098			1.6	6.8	2.3	--	--	--	--
1101			0.7	6	--	--	--	--	6
1082	50	300	26	28	27.6	16	5	--	21
1083			27	29	27.2	16	2	8	21
1084			26	29	27.4	16	2	--	21
1107			27	32	28.8	16	2	10	20
1108			27	32	29.2	15	2	8	20

TABLE IV. MAXIMUM PEAK PRESSURE AMPLIFICATION FACTOR AND CAUSTIC THICKNESS FROM F_p vs $z - z_c$ CURVES

Ave. Charge Weight (lb)	Charge Depth (ft)	Horizontal Range (ft)	Ave. Caustic Depth (ft)	Charge Diam. (ft)	$F_{p(max)}$	T_z (ft)	$\frac{T_z}{\text{Charge Diam.}}$
53.4	35	300	42.4	1.000	3.7	2.92	2.9
8.1			39.7	0.542	4.4	1.56	2.9
1.06			38.2	0.271	4.2	0.68	2.5
0.122			40.2	0.135	5.1	0.68	5.0
8.3	35	230	34.3	0.542	5.2	1.04	1.9
1.06			32.8	0.271	4.7	1.16	4.3
0.122			33.3	0.135	4.8	0.74	5.5
8.4	35	190	29.3	0.542	4.9	0.98	1.8
0.122			29.1	0.135	5.8	0.71	5.3
8.1	25*	300	59.4	0.542	4.7	--	--
1.06			59.3	0.271	5.1	--	--
8.1	50	300	27.5	0.542	4.6	0.84	1.6
1.06			27.2	0.271	4.4	--	--
0.122			29.0	0.13	5.1	0.97	7.2

* Excluding the three shallow layer shots.

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3. REPORT TITLE

Refraction of Underwater Explosion Shock Waves: Pressure Histories Measured at Caustics in a Flooded Quarry

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

5. AUTHOR(S) *(Last name, first name, initial)*

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Jean A. Goertner

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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	Defense Atomic Support Agency

13. ABSTRACT

High explosive charges were fired in a flooded quarry having a refractive sound velocity structure, in order to observe shock wave pressure histories at caustics, or focal surfaces. For such regions, present theoretical understanding and conventional acoustic ray-tracing techniques are inadequate. Peak pressure amplification factors up to 5.8 were measured; the smaller the charge, the more extreme the focusing. Energy flux density was also enhanced, but impulse per unit area was relatively unaffected.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Underwater explosions Shock waves Refraction Caustics						

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Title: REFRACTION OF UNDERWATER EXPLOSION SHOCK WAVES: PRESSURE HISTORIES MEASURED AT CAUSTICS IN A FLOODED QUARRY — 3 Dec 1969

Approved by Commander, U.S. NOL — 1 pages

C. J. ARONSON
By direction

This publication is changed as follows: On Page v

Symbol	Units	Explanation
		FROM
z	ft	depth
z_c	ft	observed depth of caustic for given shot
		TO
$z-z_c$	ft	vertical distance from caustic; this quantity is negative below caustic, positive above caustic

In footnote, page 9, change last line to (i.e., $\frac{\Delta F_p}{\Delta \text{depth}}$ vs depth).

Insert this change sheet between the cover and the title page of your copy.
Write on cover "Change 1 inserted"

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